MATERIALS & METHODS

RKING INDUSTRIES' ENGINEERING MAGAZINE

M and A

APRIL 1946

PUBLISHED SINCE 1929 AS

METALS and ALLOYS

Published Monthly by Reinhold Publishing Corporation, 330 West 42nd St., New York (18), N. Y., U. S. A. Ralph Reinhold, Chairman of the Board; Philip H. Hubbard, President; H. Burton Lowe, Executive Vice President and Treasurer; G. E. Cochran, Vice President and Secretary; William P. Winsor, Vice President; Francis M. Turner, Vice President. Price 25 cents a copy. Annual Subscription: U. S., Possessions and Canada, $2.00. All Other Countries, $3.00. (Remit by New York Draft.) Printed by Lotus Press, Inc., 508 West 26th St., New York 1, N. Y. Re-entered as second class matter Nov. 14, 1945, at the Post Office at New York, N. Y. under the Act of March 3, 1879.

RP REINHOLD

MATERIALS & METHODS

THE METALWORKING INDUSTRIES' ENGINEERING MAGAZINE

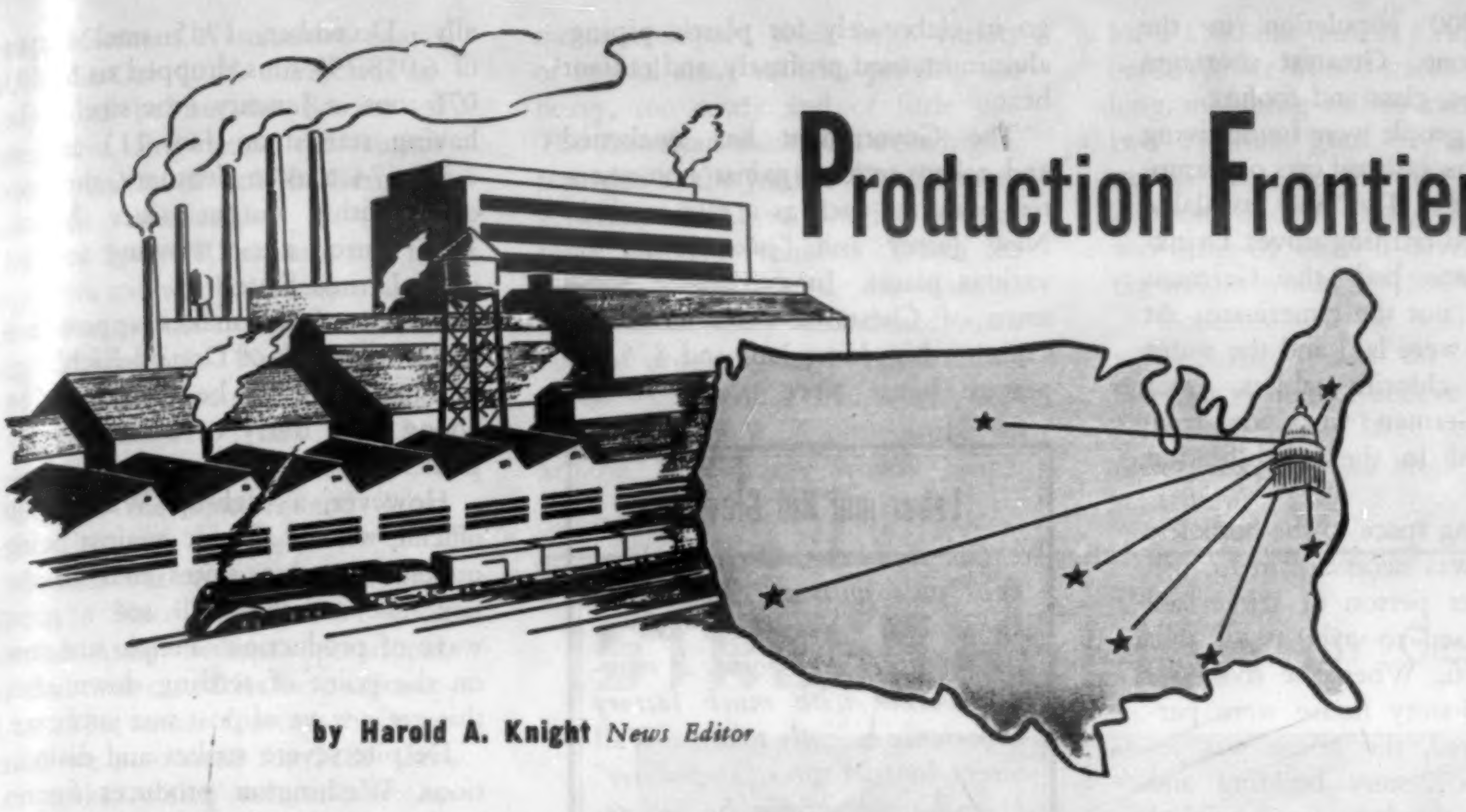
Volume 23, Number 4 — April, 1946

Cover Illustration

Engineering bronzes—the subject of this month's Materials & Methods Manual—have found wide application in transportation equipment, thus our artist shows symbolically some parts and their possible fields of application.

NEXT ISSUE:

Sodium Hydride Descaling
Porous Chromium Plated Piston Rings
Equipment for Spectrographic Analysis
Reinforced Pressure Vessels
Glass as an Engineering Material
Welding Rods by Powder Metallurgy
Precision Aircraft Gear Manufacture
Heat-Treated Rivets
Dielectric Drying of Foundry Cores
IMPACT EXTRUSIONS: "Materials & Methods Manual" No. 15



Production Frontiers

by **Harold A. Knight** *News Editor*

First step in world progress—feed and shelter the millions. . . . Hunger is worst in recorded history, comparable to Middle Ages. . . . Twelve million tons of wheat where 21 million needed. . . . Worst famine in 50 years looms for India. . . . Housing engineer returns from Germany. . . . Greatest shortages there in lumber, glass and roofing. . . . People lived in caves, barns, railroad cars. . . . Bombed 5-story houses reconverted into 2-stories. . . . May take 20 years to rebuild Germany.

In U.S.A. only veterans' housing has green light. . . . 90% of veterans want $6000 houses and $50 rentals. . . . Plywood main bottleneck. . . . 1,200,000 "vet" housing "starts" in 1946 is goal. . . . Prefabricated house builders may adopt automobile easy-finance plan. . . . Does labor demand too much kid glove treatment? . . . Steel strikes caused $120,000,000 wage loss. . . . Record production era for six months predicted as folks settle down.

Lead now whimsically called "precious" metal. . . . Other scarcities are listed. . . . We now know completely German military tank situation. . . . Cartoon: Our metallurgists receive strange visitors. . . . First authentic tin statistics. . . . We editors "take down our hair". . . . Let's take a glimpse at the Russians.

Where Is That "Wonderful World of Tomorrow"?

The high school valedictorian of 1936, hair slicked down with vaseline, orated with awkward gestures on "Wonderful World of Tomorrow". He predicted a Buck Rogers era with men working but 20 to 30 hr. per week, with all sorts of push button controls to do our every day tasks and with our foods plentiful, tasty and saturated with vitamins. His parents — and most parents — beamed with pride and agreed with him 100 per cent.

But look at this world only 10 years later! The most hunger in recorded history and the worst situation for at least 300 years! We browsed around Washington recently in a receptive mood for facts. The food and shelter situation is very much on the official mind. No world progress can be made until the people are first adequately fed and housed.

Take Europe. Nitrates were used for making ammunition and the lack of annual applications of fertilizer has reduced yields which can be brought back to the pre-war level only after several years of normal farming.

In the Netherlands, even with all other factors favorable, yields cannot rise above 65% of pre-war. About 2% of good European land is still mined, hence a frightful hazard. Farm implements have disappeared. The Mediterranean area has been drought-stricken. The Australian wheat crop is poor and that of India has failed, threatening the worst famine in 50 years.

The mild winter in Europe, a blessing on the face of things, was a curse in disguise, for it means lack of necessary moisture. The need for wheat outside the United States is for 21 million tons, with the maximum that can be supplied 12 million tons. The United States has had good crop years since the drought of 1934. Should a drought come this spring and summer it would mean the "world's greatest catastrophe."

The fuel situation in Europe is improving but is still bad. Consumers have been paying $22 a ton for inferior coal. We ship 2 million tons of coal monthly to Europe. The European miners cannot get the necessary hearty food to make them efficient.

Housing Situation: Abroad, and Here

We get a picture of the housing situation in Germany from Clifford S. Strike, F. H. McGraw & Co., New York, who has been chief of Building Materials, Construction and Forestry Office, U. S. Military Govt. for Germany. Temporary housing facilities have been provided for approximately 4,000,000 homeless Germans out

of 16,000,000 population in the American zone. Greatest shortages are in lumber, glass and roofing.

Homeless people were found living in caves, barns, railroad cars or tramping the roads. The only available heat was wood-burning stoves. Drinking water was bad—the Germans drank it, but not the Americans. At length pipes were laid and the water treated with chlorine tablets. Over 2,500,000 German workmen have been engaged in the rehabilitation program.

In allocating space to the homeless Germans it was necessary to furnish 43 sq. ft. per person of winterized space, increased to over twice that by early 1946. When the roof and walls of a 5-story house were partially destroyed, the house was remade into a 2-story building and large broken windows were bricked up, with only a small space to be glassed in. After the houses and huts were reconstructed, it was up to the Germans to provide finishing materials.

Mr. Strike states that the outlook for complete rehabilitation of Germany is far from encouraging. It may take 20 years to rebuild industries, adequate housing and to restore transportation.

But, to return to Washington again. A ban has been placed on much construction in the United States. A steel plant can't build a new plant building. A public utility may expand its service facilities, but mustn't build an office building.

A big green light has been set up for construction to house veterans. The program of the National Housing Agency is for 1,200,000 "starts" of veteran's homes this year. Ninety per cent of the veterans are in the market for their own homes under $6,000 (included, being a "fair" cost for the lot of $600) or for rentals under $50 per month. Maximum prices for the veteran are $10,000 to own, or $80 per month rental.

The greatest bottleneck in home construction is plywood, hence a price increase of 20% was granted recently to plywood manufacturers. United States Steel Corp. is erecting eight additional plants for the manufacture of pre-fabricated houses. It is possible that the makers of prefabricated houses will inaugurate an easy financing plan, the same as maintained for years by the automobile makers. Many of these houses may go in elaborately for plastic piping, aluminum used profusely, and radiant heat.

The Government has awakened and taken action against non-essential building, such as a race track in New Jersey and "juke joints" at various places. In the quaint home town of Chester Bowles, at Essex, Conn., a big dance hall and $75,000 private house were taking all the building materials and skilled labor in the vicinity.

Labor and Kid Gloves

Our social engineering has not kept pace with our techniques. Labor and management fail to see the other viewpoint. A manual worker with much factory experience recently told the Wall Street Journal *some "stupidities" of management that he had recently observed.*

One is the needlessly luxurious offices of managing personnel. Both offices and shop are places of work. Why should gorgeous offices imply so conspicuously that office workers are socially superior? Another is the lack of attention paid to the personality of a foreman. He may know well the technical side but too often he drives women to tears and men workers to grinding of teeth.

Another "stupidity" is the manner in which company action is explained to employees. At mid-December there was posted on the bulletin board: "Owing to results during the past year, no Christmas bonus will be granted." Workers took this to mean a slap at their own efficiency. Their resentment resulted in slow downs. What the management meant was that lack of good profits made a bonus unjustified.

Or, is labor too prone to expect to be handled with kid gloves? Kid gloves are scarce, you know.

Our Own Economic Situation

Our wave of strikes has been one of the most destructive upon American industry in history. Steel production is frequently regarded as an indicator of industrial activity generally. December, 1945 steel output of 6,058,799 tons dropped to 3,869,-076 tons in January (the steel strike having started on Jan. 21) and to 1,353,674 tons in February, the lowest monthly output since March, 1933. Surely a sad showing for this great United States!

Such statistics makes appropriate a recent remark of Donald Richberg: "Things seem to be run today by young in a hurry or old men in a panic."

However, a high-up Washington official, who is allergic against being quoted in print, states that in the next six months we'll see a great wave of production. People are now on the point of settling down after this great wave of post-war jamboree.

Despite severe strikes and dislocations, Washington produces figures to show that the national income is only 6% less than the war-time peak. It claims, too, that despite strikes production has been going forward. Consumer purchasing has not declined. If some articles are not available, purchasers are apparently buying other things.

Scarcities in several basic materials still plague the national economy. Lead has whimsically been called "the precious metal." Potential consumption in 1946 is 1,200,000 tons, whereas supplies in sight for this year are only 860,000 tons. The C.P.A. has suggested that consumers try to omit lead in paints and high test gasoline.

Shortage of construction materials is felt the most keenly of all. The Department of Commerce says that among steel items sheet and strip are the tightest and will be in short supply through the first half of 1946. December production of lumber fell to the lowest monthly level in ten years. Nails are in very short supply. There are no steel windows in stock.

And so throughout the list there are shortages, though in several cases production is improving.

German Military Tanks

During the war there was considerable heated controversy as to whether American military tanks were equal to those of the Germans, some of the controversy having been mentioned in this department. As Al Smith would have said: "Let's look at the record."

A paper on "Technical Investiga-

tions of German Automotive Material" by Lt.-Col. C. H. Corey was recently read before the Society of Automotive Engineers, the author having spent much time in Germany on technical missions.

"Albert Speer, Reich minister for armaments and war production, stated that Germany lost qualitative superiority in tanks in 1942 when the Mark III and IV were clearly inferior to the Russian KV-1 and T-34, but regained it from the Russians in 1943 with the Panther and Tiger tanks.

"General Patton stated on March 19, 1945: 'Since Aug. 1, 1944 when the 3rd Army became operational, our total tank casualties have amounted to 1136 tanks. During the same period we accounted for 2287 German tanks, which refutes any inferiority of our tanks. We always attacked, hence better than 70% of our tank casualties have occurred from dug-in anti-tank guns, and not enemy tanks, but enemy tanks were knocked out by our tanks. Had we been equipped with Tiger tanks the road losses would have been 100% by the time we reached the Moselle River. Actually, our road losses were negligible.'

"Production of German full tracked armored fighting vehicles rose steadily from 249 in 1939 to 19,087 in 1944, with 31,800 planned for 1945. High production in 1944 took place despite severe bombings because of the high priority which tanks enjoyed. Copper, bronze and alloy steels were always supplied on time. Even rubber did not curtail tank output. There was a slight deterioration in armor plate due to use of open-hearth in place of electric steel. The tank industry did suffer heavy bombing losses by the end of 1944 because of destruction of transportation.

"At that time, too, there was forced a change-over from nickel-chromium to moly-chromium for gear wheels, more careful heat treatment compensating. The shortage of brass for radiators was overcome by Opel's development of good steel radiators. The shortage of sheet steel was met by reducing the size of headlights, and regulations regarding rear lights, stop lights and central greasing were modified. Drivers' cabins were made of wood pasteboard and reinforcing steel bars. During the last three months there was no rubber.

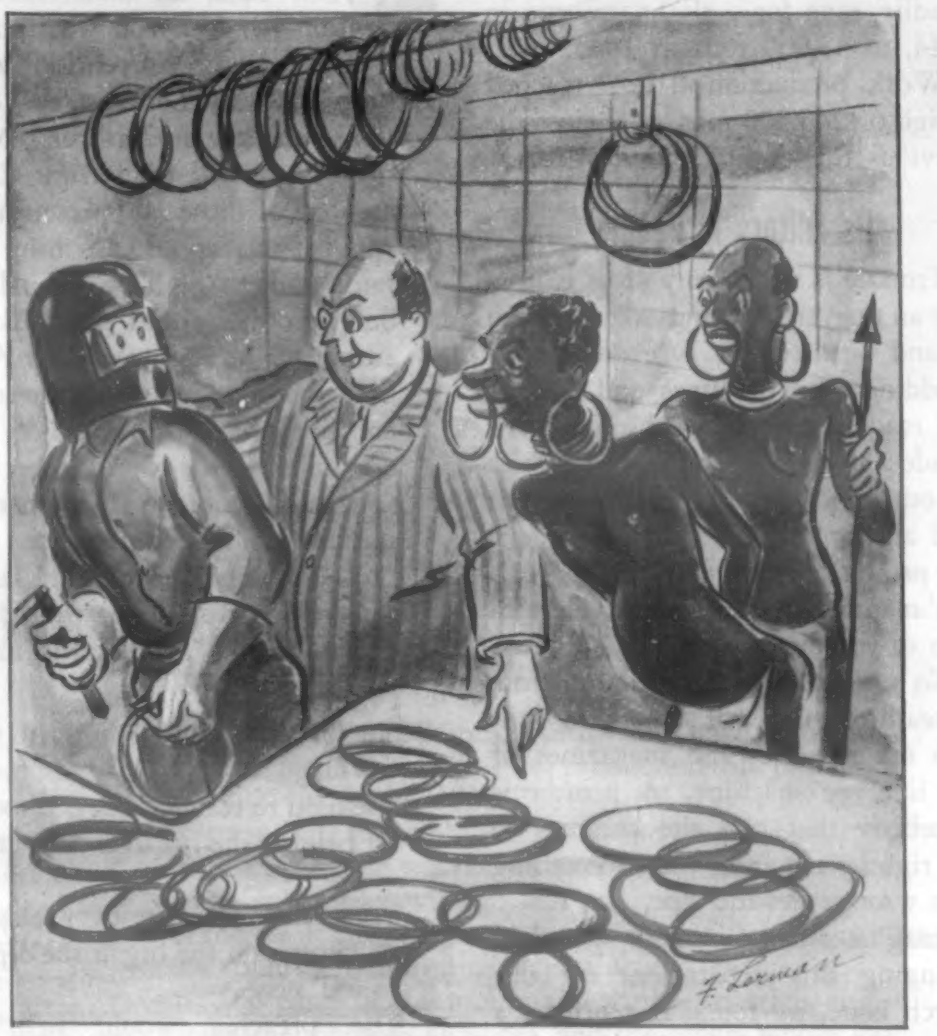
"Germans fell down in regular motor transport, their large variety of special army vehicles proving too heavy, too costly and of little use. The American transports were highly regarded by the Jerries. The Germans generally failed to provide enough spare parts for vehicles. When the Germans encountered the Russian T-34 tanks, they abandoned their current program and began building 50-ton tanks with T-34 features, such as thicker armor, sloping armor all around, large bogey wheels, longer barrelled guns, greater radius of action, and rubber-cushioned wheels.

"Because of Hitler's love of the grandiose some super-heavy tanks were produced, but by mid-1944 further work was stopped, German tank specialists deciding on 50- to 80-ton tanks. One of them weighed 200 tons, was to mount a 128-mm. gun and have front armor 8 in. thick.

"The most spectacular was a layout for a 1500-ton tank at Krupp, a land battle cruiser with 6 tracks and 75 ft. long, mounting an 800-mm. gun and two 150-mm. guns in rear quarter turrets. The front armor was to be 250-mm. thick at 45 deg. The project was dropped when it developed that the weight would be 1800 tons.

"Volumes will be written as to why Germany lost the war. Key German personnel believe that overconfidence was a large contributing factor. The German High Command had calculated that the war would be won in 1941 based on the ease with which they over-ran Poland, Czechoslovakia and France. Production schedules were based on this assumption. Hitler underestimated the power of the British Empire and, much more, that of the United States. He regarded America as a mass of individual immigrants, as yet not fully consolidated."

STRESS RELIEF By Gilbert



"They want to know how you control the formation of excessive martensite particles in the heat affected zone."

Truth About Tin: Statistically

The first authentic statistics on tin in several years have just been issued from the statistical office of the International Tin Research and Development Council, The Hague. According to its statement, owing to destructions done to several large smelters, the world's smelting capacity will presumably show a temporary decline which is counterbalanced, however, by the fact that "an American-owned smelter of great capacity was established in the U. S. A."

Interesting figures reveal the extent of the sparing of tin and use of substitute metals and materials in the United States. Thus, consumption of 100,870 long tons in 1941 shrank steadily, save for a slight upsurge in 1944, to 33,000 tons in 1945.

World production in 1941 reached a high of 245,500 tons, as against the previous top of 209,100 in 1937.

Us Editors Is People

Trouble is with many of us editors it is an uneven give-and-take between us and our readers. We are always prodding into the lives and acts of our readers and hide behind a stern facade any human quirks and foibles of ourselves. And if editors seem cold and impersonal to their readers, the printers, who set up in type editors' manuscripts, seem positively subzero to ye editors.

To us a printer is an automaton, a breathing gadget of some kind built into the matrices and magazines of the linotype machine. A printer is somebody that gets the commas in the right place and, when something goes wrong, pies the type.

Imagine our amazement, when in arranging this department for our March issue, we found our printer a living human thing. We had just received page proof on the item, "Foundryman-Singer," which reads: "It took a Big Three meeting, for instance, to reveal that our own Harry S. Truman is a piano player, who tickled off some sweet ivory music in front of Stalin, et al."

Now on the margin the printer had written in blue pencil a big question mark and the comment: "His talents were revealed a few months before he became president. Re: publicity Lauren Bacall, she sitting on piano while he is playing. One-page photo appeared in *Life,* as 'Picture of the Week'."

Rather meekly and lamely we wrote back an answer: "Thanks for your comment. We remember the photo in *Life.* We meant that the Big Three meeting is the first time the *whole world* discovered his ivory talents".

Leaving this trivia, let us give you a picture of some 100 editors in the South American Room, Hotel Statler, Washington. The night, one in mid-March. By way of introduction let us comment that when a cub reporter in Syracuse we "covered" many conventions in that center-of-the-state city. All were the conventional conventions—dry speeches, badges on lapels, a little more tipping and tipsying than usual.

Then came an undertakers' convention—and the lid was blown off.

The editors convention was not quite midway between the conventional and the undertakers. Mention "We Never Mention Aunt Clara" to any one of those 100 present and you will get in response anything from a faint smile to a guffaw. Donald Richberg, former head of NRA and author of the Railway Labor Act, was both main speaker of the evening and soloist in full bass voice. Mimeographed words were at each plate and each chorus was augmented by thumps of silverware upon tables.

We present the first and last stanzas and chorus. (Solo in basso profundo nabisco and chorus in gusto, vulgario, pocono.)

She used to sing hymns in the old village choir,
She used to teach Sunday School class,
Of playing the organ she never would tire,
Those dear days are over, alas!
At church on the organ she'd practice and play,
The preacher would help when around,
His wife caught him pumping the organ one day,
And that's why Aunt Clara left town.

CHORUS:

We never mention Aunt Clara,
Her picture is turned to the wall,
Though she lives on the French Riviera
Mother says that she's dead to us all.

Her dear Mother's life has been pious and meek,
She drives in a second-hand Ford.
Aunt Clara received for her birthday last week
A Rolls Royce, a Lincoln, a Cord.
Her Mother does all of the house work alone,
She washes and scrubs for her board,
She reached the conclusion that virtue's its own
And also its ONLY reward.

Industrial Expansion in Russia

We are concerned these days with the prospects for Russia to rival us technically and industrially. Though her progress during the war is an enigma, interesting pre-war figures are available. In 1938 Russia had 902 scientific institutes, with a combined staff of over 80,000. In that year the Great Bear appropriated over 1,000,000,000 rubles for scientific research as against 1,500,000 rubles in 1917.

Universities have increased from 91 to 716 during the past 25 years, with enrollment of 601,000. Russia claims many fundamental discoveries, including butadiene, the foundation upon which the synthetic rubber industry is built.

Since the war Russia, the bear, has been as busy as a beaver in building new enterprises and reconstructing and expanding older industries. Most marked activity is in nonferrous metals, ferrous metals, coal, machinery, transportation equipment, power facilities, petroleum, timber, food and consumer goods.

About 30 large new coal mines were opened during the first half of 1945, mostly in the Moscow Basin and in eastern regions. Work was begun in 1945 on construction of 14 new plants for making coal-mining machinery.

Expansion of industrial activity has taken place in almost every region of the entire Soviet Union. At least 10 municipalities in the Ukraine have restored or enlarged existing plants, or built new ones since the war's end.

The iron and steel combine in Magnitogorsk (South Urals) leads all other enterprises in this field in volume of new construction. Several concentrating plants, four new open-hearth furnaces and houses have been built. A new coke battery was operated in 1945, with several remodeled.

There have been major developments in the Soviet in copper mining and smelting, aluminum production, lead-zinc concentration, steel rolling mills, blooming mills, blast furnaces, pipe mills, railroad and farm equipment.

"No Reconversion"

A noticeable feature of the surplus tool disposal problem is the reluctance of many of the country's largest industries to buy any substantial amount of these tools. This does not mean that the tools are worthless, but rather indicates, in the opinion of many leading sales engineers, that industry demands tools especially engineered for the performance of one operation or group of operations in the production of a specific item. Highly efficient mass production methods have built the superiority of American industry over foreign competitors, and the high standard of living that goes with it.

For such industry, when new products are to be produced for peacetime consumption, it is not feasible simply to buy up second-hand standard equipment and fit it to manufacturing. At a press conference in Cleveland, C. V. Briner, president of the American Society of Tool Engineers, said, "There can be no reconversion. Reconversion means going back—and we can't go back." Industry must redesign and retool for maximum benefits from the mass production system.

Speaking of the place of the tool engineer in industry's peacetime plans, Mr. Briner said, "Health insurance, free shoes, bonuses, and the like have all helped to achieve the miracles of production of Jack and Heintz (in Cleveland). But the real reason for their success is that Ralph Heintz is one of the best tool engineers in the world. He wouldn't attempt to make even an ashtray without first studying it, suggesting some small change in the design here or there so that he could fit it into a mass production scheme."

The place of the tool engineer, the materials engineer, the methods engineer, and the others whose job it is to plan mass production has already been mentioned in this section ("Mass Production for Peace," July 1945, page 65). Theirs must be the job of redesigning American industry for the production job ahead. The system requires tremendous capital outlay —it has been estimated that $5000 is invested for every American workman employed—and industry must have sufficient encouragement from both government and labor to warrant making that outlay, for when American industry has made the outlay, the engineers have laid out the production lines and designed the tools, and labor operates them, the system can guarantee an abundance of goods for all at the lowest possible costs.

—K. R.

Work To Be Done

With the introduction during the past few years of a number of new non-destructive testing methods, the ever-present problem of developing standards for the interpretation of results in tests of this kind—radiography, magnetic particle inspection, fluorescent penetrant methods, and now supersonic and electronic methods—has been greatly magnified.

The usefulness of these non-destructive tests as material inspection tools is to a great extent dependent upon reliable standards developed from actual experience and experimental data. Many of the standards already established for non-destructive tests are still arbitrary. They are not derived from comprehensive experiments, but instead are based, in many cases, upon the personal opinions of the group compiling them. This was an expedient method of arriving at standards and was justifiably condoned during the war years, because there was insufficient time to proceed any other way. Now that so many new developments in the field of non-destructive testing have appeared, it will probably be necessary again to at first select standards arbitrarily until a better job can be done.

The development of accurate standards which are based upon correlation between test results and actual service conditions is no easy matter. It requires lots of time; it takes the concentrated and coordinated efforts of many interested groups who very often have diverse points of view. But the job can and must be done, otherwise the excellent non-destructive testing methods developed during the past decade or so will lose much of their value.

This necessary work should be attacked vigorously and expedited. It should head the work-to-be-done lists of all societies and groups concerned with materials inspection. —H. R. C.

Pennywise and Pound Foolish

What brought forth a cascade of thoughts on this subject was the statement made the other day to us by an official of the Haynes Stellite Co. He was telling of a critical war situation following destruction by fire of equipment for making 100-octane gasoline. More isomerization pressure vessels had to be built in a hurry and one of the successful solutions was the lining of ordinary steel vessels with Hastelloy metal which resists the common acids and other corroding chemicals. The same vessels were used also for making neoprene, isobutane, various styrenes and related products.

The significant point is that the initial cost with Hastelloy lining was $20,000 per vessel in excess of that of the material previously used. However from the standpoint of long life the higher initial cost was more than justified. Some of these vessels have by now been used constantly for two years with no sign of serious deterioration.

One hopes that the world will become more quality conscious for its own good, laying not too much emphasis on original cost, but rather being cognizant of overall costs. One of the aggravations of the average motorist is that the muffler frequently corrodes and must be replaced. The automobile manufacturer answers that no automobile buyer ever is concerned with the quality of the muffler, at least at time of purchase. Why spend money on improving its quality in the highly competitive automobile field? Yet there are several fairly simple materials that would be a marked improvement over present mufflers.

Take the conservative railroad industry. The carriers have been much too slow in adopting the lighter weight low-alloy steels for improving freight car quality, evidently fearing that greater first cost would not be justified. Tests have in many cases shown that they were mistaken. A generation ago makers of galvanized steel were putting just enough zinc coating on their sheets to get by. Travel through the countryside revealed, therefore, hundreds of ugly barns and other farm buildings where dirty rust was showing through the zinc. At length the American Zinc Institute raised standards, insisted on 2-lb. coatings and gave its "Seal of Quality" to all makers who conformed.

The trouble has been due in large part to a conception on the part of some manufacturers that goods must not be made too everlasting, else there will be no replacement business. Even in 1946 makers of horseshoes were advised of much better materials than ordinary stainless steel, but they turned it down. It was "too good."

We maintain, however, that using anything except the best for the job at hand is a short-sighted policy. In view of consumers' research movements, greater and more universal technical knowledge of the average citizen, and greater universal striving towards perfection, that manufacturer who makes and that consumer who buys anything except that containing the best material, is not keeping up with the procession. Such a person is "pennywise and pound foolish." —H. A. K.

AN EDITORIAL

The "Show" (Plastics or Metal) Must Go On!

This month we welcome to the great company of important industrial expositions The Plastics Show, which in many ways symbolizes the maturing of a material and the beginning of an era. We welcome it even though our feet have but recently recovered from trudging the arenas and aisles of another show—the Metal Show—and despite our vague uneasiness over the increasing number and frequency of "Congresses" and "Expositions." We welcome *this* new show chiefly because it is long overdue and because it can be as great an asset and boon to the plastics industry and its customers as the Metal Show has largely been to the metal producers and *their* customers over the past two decades.

We are not among those who prophesy that the "age of plastics" is upon us and that these modern materials will in time replace metals, especially steel, as the basic materials of industry, construction and our daily lives. So far as we can see plastics will continue to be subordinate to metals in production tonnage and commercial importance for generations. But we do perceive that the field of engineering materials for industry, once populated entirely by metals, now includes several nonmetallics — and especially certain plastics — and that the importance of plastics as engineering materials will henceforth increase as materials engineers come to know them better and learn to apply them, in conjunction with metals, in their products. The Plastics Show thus becomes a highly desirable, indeed an *essential* factor in furthering such education among materials men, as well as stimulating the development of additional and ever better plastics materials for all to use.

The Society of the Plastics Industry has shown both courage and foresight in instituting its first full-scale exposition at this time, with the country in a state of suspended industrial animation and the future as uncertain as it seems to be. "The show must go on!" is happily more than an old trouper's slogan. We hope in this and in its future performances that this newest Show will be guided by the experience of older expositions and by the wishes of the industries that will support and maintain it — that it will, indeed, evolve a program guided by two simple principles: (1) rigid adherence to the basic purpose and scope originally planned, and (2) allowing a sufficiently long interval between shows (for example, two years instead of one) to permit the exhibiting of really new products and processes throughout most of the Show each time it is held.

Just as plastics have joined their big-brother metals in the family of engineering materials, so also has the Plastics Show joined the Metal Show as another important exposition in our field. We wish the newcomer well (a Preview of the Show starts on page 927 of this issue) and hope it may profit from the experience of its older and larger counterpart.

FRED P. PETERS.

Many of the prefabricated houses planned to ease the housing shortage are being designed to use plastic piping, such as this one of Saran. (Courtesy: The Dow Chemical Co.)

NONMETALLIC MATERIALS

Plastics as Engineering Materials

by JOSEPH SHERMAN, *Associate, Herbert R. Simonds, Consulting Engineer*

AMONG THE MANY changes that have occurred in recent years in the ever-changing field of plastics, two trends are outstanding. The first is the development of a number of new materials and processes which have widened greatly the range of properties and applications. The second is the graduation of plastics as a group into the class of engineering materials. These two trends have gone hand in hand and both were given a sharp impetus by the war which put a new emphasis on materials possessing high strength characteristics, dimensional stability, and other engineering requisites.

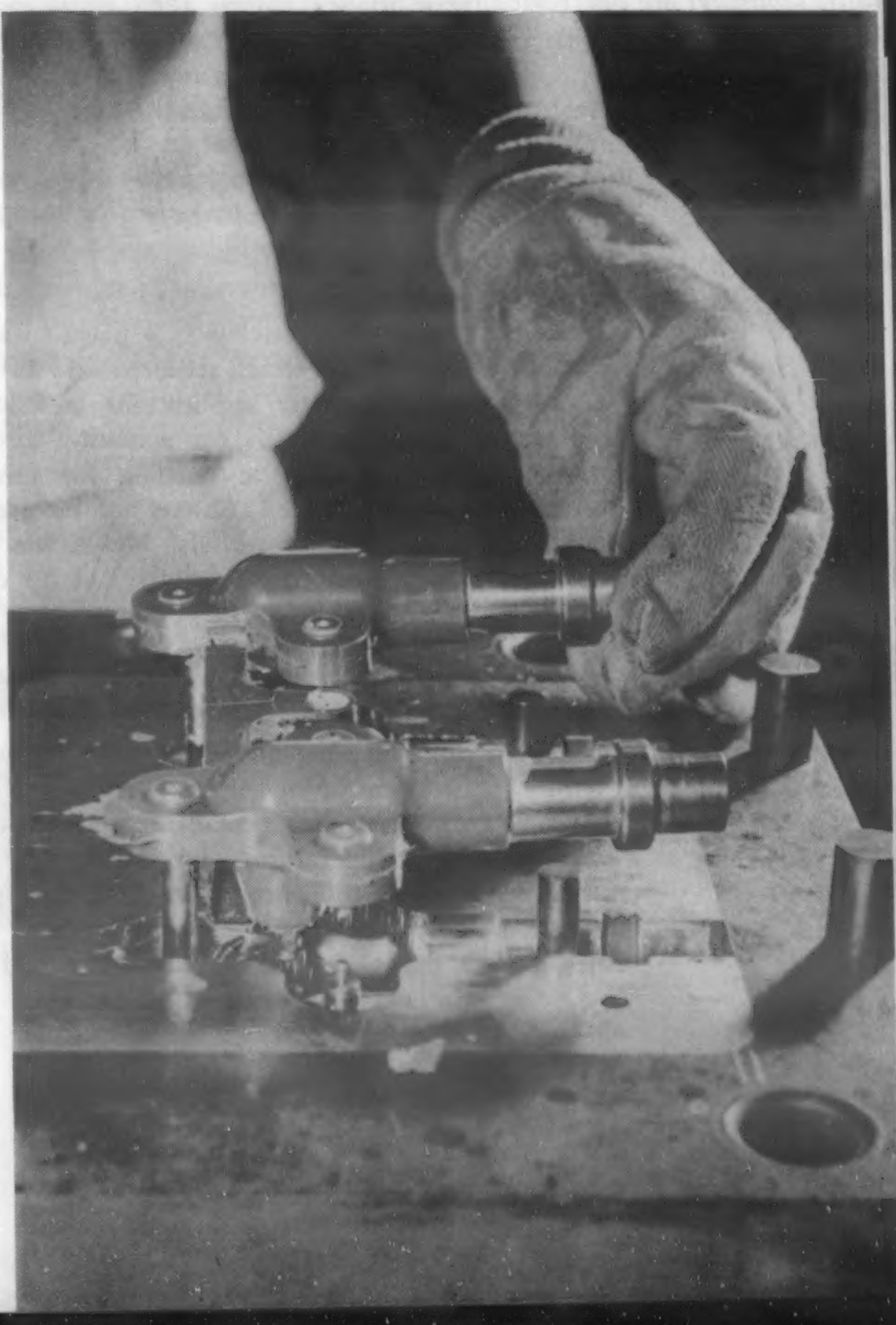
For practical purposes, "plastics" may be defined as chemical compounds which are plastic under certain conditions, so that they can be shaped and then set in a more or less rigid form. The two principal divisions are: thermosetting (heat-hardening) and thermoplastic (heat-softening). In all, there were about a dozen types of plastics materials in use before the war. The thermosetting materials included the familiar phenolics (often termed the "work horse" of the industry) and the colorful ureas. The melamines were just coming into the picture. The thermoplastic materials included: the cellulose materials—nitrate, acetate and acetate butyrate, the vinyls, polystyrene, the acrylates, and casein.

During the last four or five years, several interesting new types of plastics have been introduced. These include vinylidene chloride, new types of melamines, allyl resins, polyethylene, nylon, and the silicones.

The adaptation of plastics to engineering uses is well illustrated in the case of the new melamine molding materials. Before the war, only the cellulose-filled type of melamine molding powder was available. This was all right for tableware and buttons, but it was not suitable for mechanical parts where resistance to high temperatures and good electrical properties were required. To meet these needs, new mineral-filled types of melamine molding powder were developed. Because of their outstanding electric arc resistance, they found wide use during the war in aircraft engine parts. In addition to molded products, melamine resins are used to make laminated products, to bond plywood, to increase the wet strength of paper, and to treat woolen goods to reduce shrinkage.

Vinylidene chloride is another new material which is extremely versatile. A thermoplastic, it can be molded or extruded in a number of forms and shapes. The material is characterized by outstanding resistance to chemicals. Injection-molded parts were used during the war to replace such strategic metals as nickel, aluminum, and stainless steel in applications requiring chemical resistance. Some of these applications were spray-gun handles, valve seats, acid dippers, and various moldings for the rayon industry. The material has good mechanical characteristics.

Plastics and the metals are essentially complementary materials rather than competitors, each group having certain characteristics that the other lacks.



Glass cloth laminate is used here for the bottle holder on packaging machinery. Produced by Laminated Plastics, Inc., these units are installed on labeling machines made by the New Jersey Machine Co.

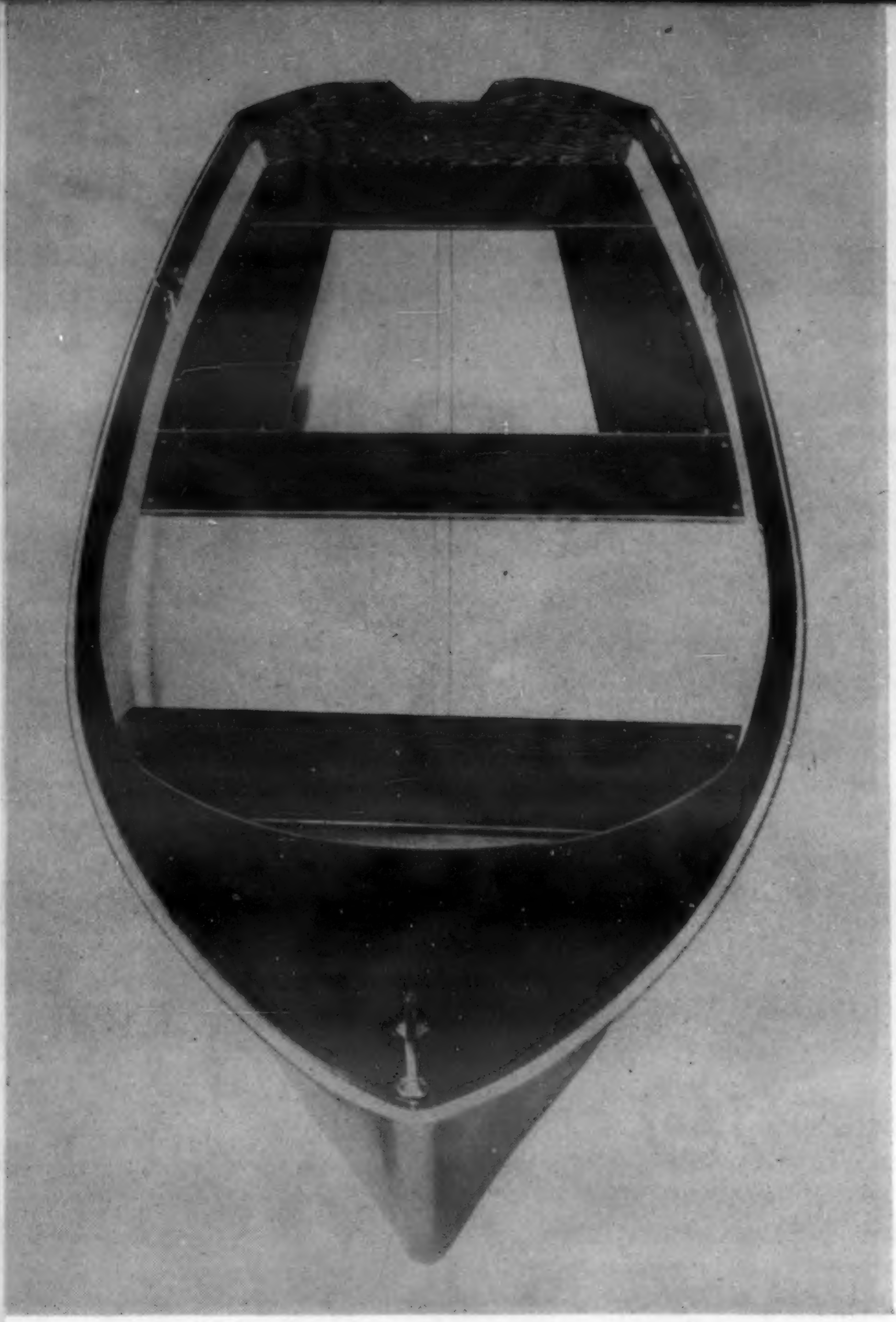
Melamine formaldehyde insulating materials are widely used for aircraft ignition parts such as these (lower photo), connector blocks. (Courtesy. Shaw Insulator Co.)

In extruded form, vinylidene chloride was used to make chemically resistant flexible tubing and pipe, gaskets, conveyor belts, tape and strips for die cutting, and other industrial products. It was also drawn into monofilaments for use in filter fabrics, special ropes, screening, and upholstery fabrics.

Allyl resins can be cast into clear sheets that are about the nearest thing to glass yet developed (although they lack the surface hardness of glass); or they can be made into various laminates. The allyl resins played an important part in low-pressure laminating during the war, and aided in the development of new structural materials which will be discussed later.

Polyethylene with a specific gravity of 0.92 is the lightest of all plastics resins and the only one that will float in water. Although it was first used principally as a coating material for high-frequency electric wiring and cable, it can be readily molded by injection or by compression, or extruded in the form of sheets, films, fibers, or tubes. Its important properties include flexibility and toughness over a wide range of temperatures, unusually good resistance to water and to penetration by moisture, chemical inertness, and unique electrical properties. A peculiarity of polyethylene is that in thin sections it is nonrigid, but in thick sections it ranks among the rigid plastics. Suggested applications of interest to the engineer include: flexible tubing or more rigid piping, as well as various electrical uses.

Nylon plastic is far less familiar than the textile. It is characterized by extreme toughness and high temperature resistance. While most thermoplastics soften at about 160 F, nylon does not soften below 450 F, and molded articles retain their form stability



lastic laminates are being used for many new marine applications such : this dinghy produced by Winner Mfg. Co. (Courtesy: Bakelite Corp.)

to 350 F. Its softening point is about equal to the charring point of some of the thermosetting materials.

Nylon as a Plastic

The first application of nylon as a plastic was in rayon plants for bearings which required no lubricant other than water. Military applications included a spool used for winding coils for actuating aircraft instruments and a switchette housing for electric equipment. The thin molded sections had far greater strength than most other materials. Nylon was also used in the form of tubing, and films, and for coating electrical wires and fabrics.

Perhaps the most revolutionary of all the new plastics are the silicones. Unlike other plastics which are built around the chemical element carbon, the silicones are based on silicon, which is more abundant in nature than carbon or any of the metals. The silicones have two outstanding properties: stability over a wide range of temperatures (up to 500 F), and unusual resistance to moisture. They have been produced in a variety of forms including resins, varnishes, greases, fluids, and rubber-like materials. They had important war applications where no other materials could have met the requirements.

While it is too early as yet to say just what the ultimate importance of the silicones will be, their development is regarded as one of the outstanding scientific accomplishments of the day. They will undoubtedly find many uses as coating and laminating materials for the electrical, chemical and textile trades.

All of these new materials have helped to extend the range of applications for plastics. It is noteworthy that all of them were designed to meet real engineering problems arising out of the war, rather than to furnish alternatives for the materials already in existence. Many of them can do jobs which no previously known materials had been able to perform.

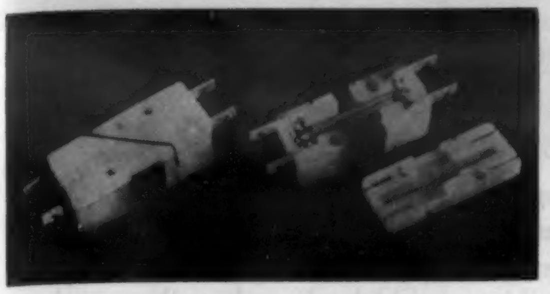
The older types of plastics have also felt the effects of the increasing demand for materials with greater strength, higher heat resistance, and other properties required for engineering applications. A new high-impact phenolic utilizing a string filler has a rated impact strength from 20 to 25 times that of general-purpose phenolics. An improved casting phenolic has made possible the use of plastics drill jigs and forming dies. New types of methyl methacrylate molding powder and polystyrene have been developed that are capable of withstanding higher temperatures than the older materials. Cellulose acetate having increased water-resistance and dimensional stability has been produced.

A significant development was the increase in the size of molded products. Before the war, a molding of 2 ft. by 3 ft. was considered quite large, but since then moldings of 3 ft. by 5 ft., or larger, have been made. And new processes have opened up the possibility of producing much larger pieces.

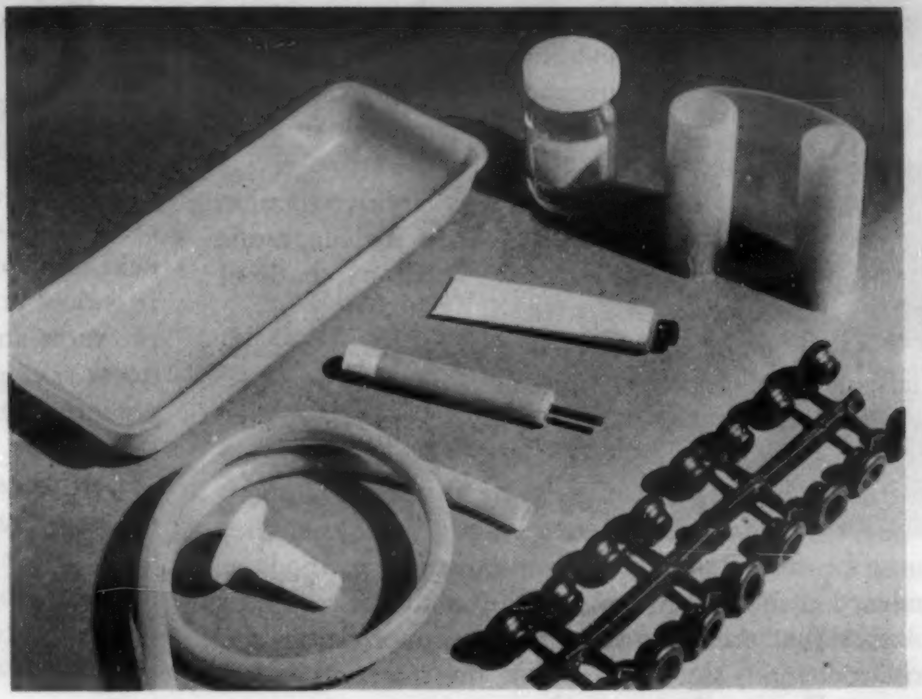
But it is not when used alone, or in the form of molded or fabricated articles that plastics have their greatest possibilities. For one thing, they are too expensive compared with other materials. Their greatest promise is in the industrial field in combination with established materials such as metals, wood, and glass.

Indicative of the increased industrial importance of plastics is the fact that about 80% of all plastics materials are now used by industry in the form of surface coatings, adhesives, and laminates, while only about 20% go into molded or consumer products. Before the war, a considerably higher proportion of plastics went into molded articles.

A prominent engineer recently expressed the opinion that we are now on the threshold of a new structural era. The period from 1860 to 1880 was characterized by great progress in civil engineering, that from 1880 to 1900 in mechanical engineering, that from 1900 to 1920 in electrical engineering, and that from 1920 to 1940 in chemical engineering. The period from the end of the war to 1960 may be marked by great progress in the construction of homes, household equipment, furniture and other



Nylon is used in these injection molded switchette housings which withstand heat and strains in thin, intricate walls. (Courtesy: Du Pont Co.)



The ice cube tray, jar top, bottle stoppers and other parts illustrate some possible uses of Du Pont polythene. (Courtesy: Du Pont Co.)

structural goods. This has been called "the century of the common man" and there can be no doubt that he needs more of these things.

New Structural Materials

The plastics industry is creating a host of new structural materials. New adhesives make it possible for the first time to bond metals, wood, glass, ceramics, leather and rubber into composite structures. Perhaps the role of plastics in providing these adhesives is symbolic of the part it will play in the future in bringing together into composite structures many diverse materials so that the best properties of each may be fully utilized.

New plastics adhesives are helping to transform wood into an engineering material. Lumber in a natural state has many defects, which have been responsible for its declining use. It shrinks and swells, warps and cracks, and is subject to destruction by fire, insects and the elements in general. It lacks uniform strength and is only one-twentieth as strong across the grain as along it. The development of improved plywood and other forms of wood utilizing synthetic resins has done much to help overcome some of the natural limitations of wood.

One of the most important developments has been that of exterior plywood, made possible by the use of waterproof resins. While exterior plywood was introduced in 1934, it did not come into wide use until the war, and as late as 1940 only 4% of Douglas fir plywood production was of the exterior type. Since then, it has literally gone places in the shape of the torpedo boats, assault craft, barracks, huts, and pontoon bridges. Output of exterior plywood had to be expanded sevenfold, and by 1945 it accounted for nearly 30% of fir plywood production. It undoubtedly has a big future in homes, commercial and farm buildings, boats, trucks, and railroad cars.

Plywood tubing, first produced commercially in 1942, also was made possible by the use of plastics adhesives, which allowed sufficient slippage in molding to make tubing manufacture practical. This tubing was used in masts for radio and radar installations. A 75-ft. plywood mast weighing 230 lb. replaced a metal mast weighing 1980 lb. Plywood pipe, because of its great strength, light weight, and resistance to chemicals, can be used to carry liquids or gases that would quickly corrode metal.

Many new structural materials have been developed by combining wood and paper with plastics. "Impreg" is resin-impregnated wood that has the advantages of greater hardness, compressive strength, and dimensional stability compared with ordinary wood. "Compreg" is resin-treated wood that is compressed prior to the hardening of the resin to give it greater density and strength, along with increased dimensional stability. "Papreg" is an improved resin-impregnated paper-base laminate that has practically twice the strength of earlier commercial types. It might be termed "structural paper," since it has adequate strength for many semi-structural and some structural uses. Papreg found its chief war uses in aircraft flooring and semi-structural interior parts of planes such as gunner's seats and turrets. Compreg was used in airplane propellers. All of these new materials have good strength properties and are suitable for a number of peacetime structural uses.

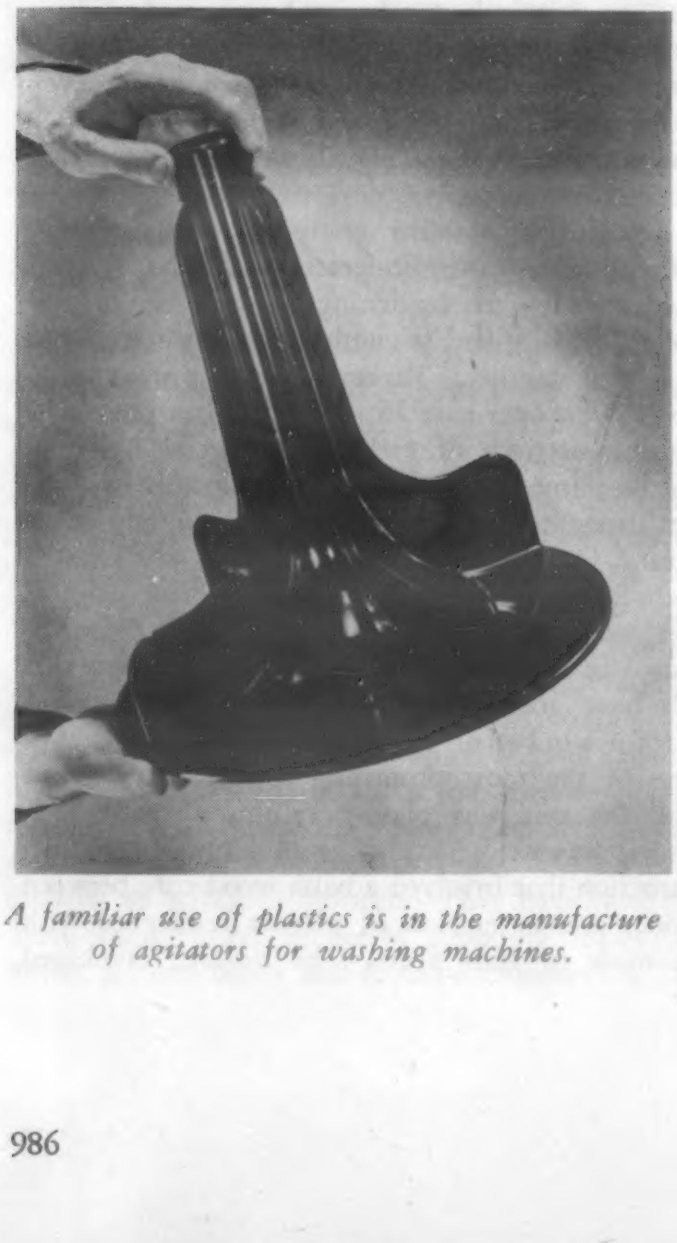
One of the most promising materials developed during the war was plastics reinforced with glass fibers. It was used successfully in a type of aircraft construction that involved a balsa wood core between an inner and outer skin of plastics reinforced with cloth made of glass fibers. The material combined

very high strength with low weight, a highly desirable combination in modern engineering materials. It is said that several automobile manufacturers are planning to use glass-fiber plastics laminates in automobile bodies.

A number of other fibers are under investigation for use in reinforcing plastics. They include ramie and saponified cellulose acetate (Fortisan), both of which have high tensile strength.

Paralleling the development of new plastics materials and combinations, has been that of new processes, which, by increasing production, improving final product, and reducing costs, should widen further the use of plastics as engineering materials. If plastics are to come into widespread general use, they must be turned out by mass-production methods at reduced cost. It is in the molding and fabricating of plastics that there are the greatest opportunities for cost reduction, since the cost of the materials is less than half that of the molded or fabricated article.

Among the new processes are electronic heating of molded parts, low-pressure molding of laminates, and continuous extrusion. Electronic molding reduces cost not only by speeding up production and thereby requiring less expensive mold cavities for a given rate of output, but also by reducing rejections. In addition, it opens up the possibility of making more complicated and larger pieces than have been feasible in the past. Electronic molding is generally considered the most important single development in the plastics industry in recent years.



A familiar use of plastics is in the manufacture of agitators for washing machines.

Low-Pressure Molding Increases Sizes

The low-pressure molding of laminates supplements high-pressure molding and thus enlarges the field of application for laminated plastics in general. It is now possible to mold laminated products at low pressures and at reduced temperatures with a consequent saving in die cost and a great expansion in size potentialities. All of this means greater output at lower cost.

Low-pressure molding was used during the war to make many diverse laminated parts such as gasoline tanks, airplane wing tips, pilot seats, doors, flooring, air ducts, and small boats. It is considered feasible for making bathtubs, ventilating ducts, refrigerator cabinets, lockers, luggage, and many other items.

The future of plastics lies largely in laminated materials, for it is here that large size of parts, strength, and lightness of weight, can be combined with economy of production. This was recently brought home strikingly to the writer when he saw a good-sized "plastics" outboard-motor boat offered at $245, a price comparable with that of other materials.

Plastics laminates will be used in many applications instead of wood, metals, and other structural materials. However, it should be borne in mind that the volume of plastics produced is still very small compared with that of steel and lumber, so that competition should not be serious for those industries.

Plastics and metals are essentially complementary materials rather than competitors. In spite of all the new high-strength materials that have been developed, the metals are still in a class by themselves for all-around strength characteristics. They have better dimensional stability than plastics. But plastics generally have the advantages of lightness of weight, chemical stability, and color and appearance.

Because of the great dissimilarity between the two classes of materials, the number of applications permitting a choice will be quite limited and the zone of competition a narrow one. But where a choice must be made, not one property, but a great many different factors will have to be taken into consideration. The final decision will involve some compromise not only as regards properties of the materials, but also as regards relative costs of materials and fabrication.

The new materials give the designer and fabricator a much wider choice than ever before. He now has a greater range of structural materials from which to choose those which will best meet the requirements of a particular job. It is important that he be open-minded in his selection and consider the possibilities of plastics wherever they are definitely indicated.

Sinteel "G," a copper-iron material, has many valuable properties including pore-free structure, high strength, hardenability and excellent machinability.

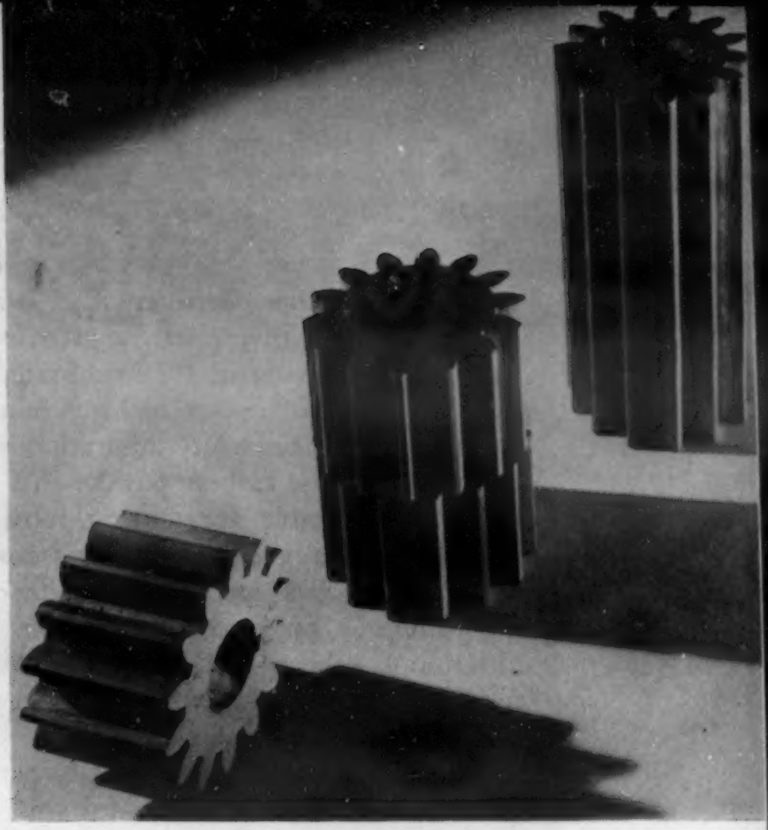


Fig. 1—Three variations on the same theme possible with cemented steels—at left, a single-unit Sinteel "G" spur gear; center, an offset gear made by assembling two green pressed gears and infiltrating-and-brazing them together; right, an exceptionally long spur gear made by infiltrating-and-brazing together three green pressed gears with the teeth in alignment.

POWDER METALLURGY

Cemented Steels—

A New High-Strength Powder Metallurgy Product

by FRED P. PETERS, *Editor-in-Chief,* MATERIALS & METHODS

POWDER METALLURGY ALREADY boasts many products with duplex structures such as electrical contacts and cemented carbides. A new one has now been added which combines two of our most important basic metals—iron and copper—in a new way and gives a material with interesting and specially useful properties and production possibilities.

This new material, called Sinteel "G", initiated by P. Schwarzkopf and developed by C. G. Goetzel, R. Pettibone and other engineers of American Electro Metal Corp., Yonkers, New York, is essentially steel cemented with copper alloy. It is produced by infiltrating a porous steel skeleton (pressed from metal powders) with molten copper alloy. Low pressing pressures are used; the infiltration is accomplished by penetrating the steel skeleton with the liquid copper alloy and no subsequent coining operation is required. The final product is virtually pore-free and in the as-infiltrated state has tensile strengths of 50,000 to 100,000 p.s.i. It may be quenched-and-tempered or case-carburized, and it also has the precipitation-hardening properties of iron-copper combinations. By using these heat treatments, alone or together, tensile strengths up to 170,000 p.s.i. can be obtained, according to tests made by American Electro Metal Corp.

One of the most interesting characteristics of these cemented steels is their amenability to brazing, without an externally applied brazing alloy, since they carry their own "brazing alloy" as part of their essential structure at all times. Through the use of this feature, parts have been economically produced as composite assemblies that are larger or longer or more intricately shaped than could be produced by conventional powder metallurgy methods.

Also, because of its virtually pore-free structure, the new material has been found to be readily machinable. On the other hand, it can also be decopperized on the surface to provide a porous surface if oil-retaining characteristics are desired.

The cemented steels, however, are not quite so simple as the foregoing brief introductory description might imply. Specialized techniques must be used in their production. There are maximum and minimum size limitations for unit pressings. There are also certain fields of application or types of part for which the cemented steels are not recommended, at the same time that there are other uses and products for which they would appear to be ideal.

Production Technique and its Development

As is well-known, neither the idea of infiltrating a molten metal into a porous sponge of a higher-melting material nor the use of iron and copper together, is new.

The cemented carbides are classic examples of a high-melting constituent, cemented by a lower-melting bonding agent. With respect to infiltration the

record shows that Gebauer in 1916 impregnated iron skeletons with copper, tungsten with silver, etc. and that Baumhauer in 1922 infiltrated tungsten carbide sponges with lower melting cementing metals. But to achieve satisfactory infiltration Baumhauer had to use such coarse carbide powder that the final product was unsuitable for cutting tools (although it might have been good for wear-resistant parts); since his objective was specifically cutting tools he gave the technique no further promotion. However, infiltration has been used in this country in the last few years in the production of certain types of alloys for electrical purposes.

During the war the Navy Department sought to utilize the cemented-steel idea with a process that involved preparing copper-coated steel powder (each individual steel particle coated with copper), pressing to shape and sinter-brazing the compact at copper-brazing temperatures to yield a strong, dense material. So far as we know this development was never completed, probably because of difficulty in producing a suitable coated powder.

What *is* new in the development of Sinsteel "G" is the successful application of the infiltration technique to the production of dense parts made of steel or iron cemented with copper alloy. In the process as now carried out, the iron powder or mixture of iron and graphite powders is pressed to final dimensions at pressures between 20 and 45 tons per sq. in. If the compact contains carbon (i.e. if it is to be a steel skeleton rather than iron) it is separately presintered at the temperature later to be used for infiltration; this not only eliminates the carbon oxide gases in advance of the critical infiltrating step, but also makes control of dimensions much easier. The compacts are then impregnated by contacting their lower surfaces with molten copper alloy held in special refractory containers while the latter move downward at controlled speed through a vertical continuous furnace designed especially for this work; the molten copper alloy works upward by capillary action through the interconnecting pore-network of the compact. The impregnated products are then allowed to cool slowly to room temperature and are finally given whatever heat treatment they are to receive.

Among the critical problems that had to be solved was that introduced by the affinity of pure copper for pure iron—more specifically the solubility, however limited, of copper in iron and of iron in copper. This slight alloying effect, while it goes hand-in-hand with the capacity of the liquid copper to "wet" the internal surface of the porous network of the iron or steel structure and therefore to infiltrate rapidly, also causes the formation of an "icicle" effect (through the loss of copper into the iron lattice) which makes control of dimensions very difficult. Equally distressing is the elevation of the freezing point of the molten copper caused by the increase in its iron content; this effect can be disastrous for it causes premature freezing of the copper and sealing-off of considerable parts of the porous network before impregnation is complete.

The ideal infiltrant, therefore, would be one that would wet but not alloy with the iron or steel skeleton. This being impractical, a compromise was achieved by using instead of pure copper a copper-base alloy (copper, plus tin, silicon, chromium, phosphorus or others). These additions sufficiently inhibit the solubility of iron in the copper to permit complete impregnation of the compacts without premature freezing of the cementing agent.

The iron or steel base also presented many problems. Coarse, globular iron particles must be used, otherwise the capillary network of pores will not "draw" properly or will not be completely interlocking. Electrolytic iron powder answers this requirement but gassed excessively for good infiltration and results were difficult to reproduce. Excellent results were later obtained with a commercially produced reduced iron powder, specially prepared to simulate the structure of the electrolytic iron that had been found satisfactory in this respect. Today, with current refinements in the process, any grade of reduced iron powder can be used if it is not too "fluffy."

The time period for infiltration is also a critical factor. If the skeleton is too long in contact with the molten copper an undesirable gassed surface layer forms on top of the part, whereas too short a period obviously leaves a portion of the piece uninfiltrated. The gassed surface results because prolonged heating at a temperature where the infiltrant remains liquid, causes excessive absorption of the furnace gases with consequent porosity in the solidifying infiltrant phase. The time periods will vary with changes in the composition of the iron or steel skeleton or of the copper alloy cementing agent (due to changes in their wettability) and in sizes of the compact.

With the infiltration properly timed the part will be just completely impregnated when it leaves the "mold" or container and on cooling will exhibit a thin "slag" on the top surface which can be easily and cleanly lifted off by hand to leave a copper-colored surface. The bottom or intake surface of the product is sometimes of poorer quality than the "exit" face, and with some parts may require a minor refinishing operation. The molds, too, were a problem at first because the molten copper rapidly attacked them. A special type of ceramic was finally developed, for both the impregnating molds and the crucibles for melting large batches of the copper alloy. The company now presses its own molds out of this ceramic and such molds give long service.

Characteristics of the Material

In Fig. 2 and in the accompanying Table are given the physical properties of these cemented steels as found in American Electro Metal Co. tests, and espe-

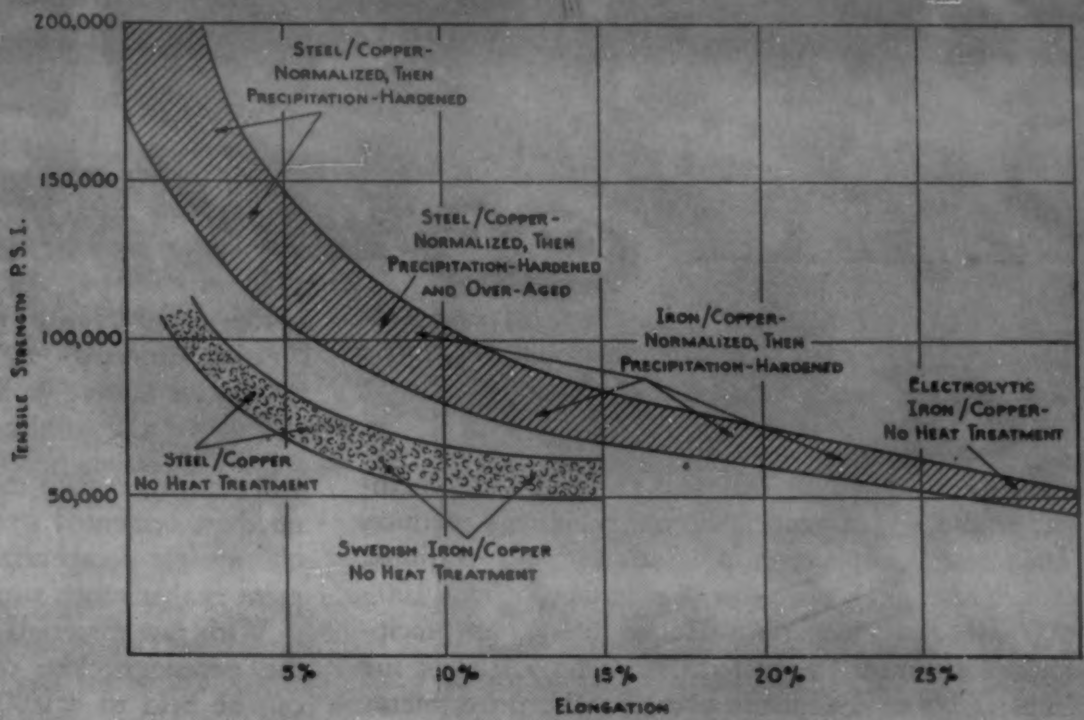
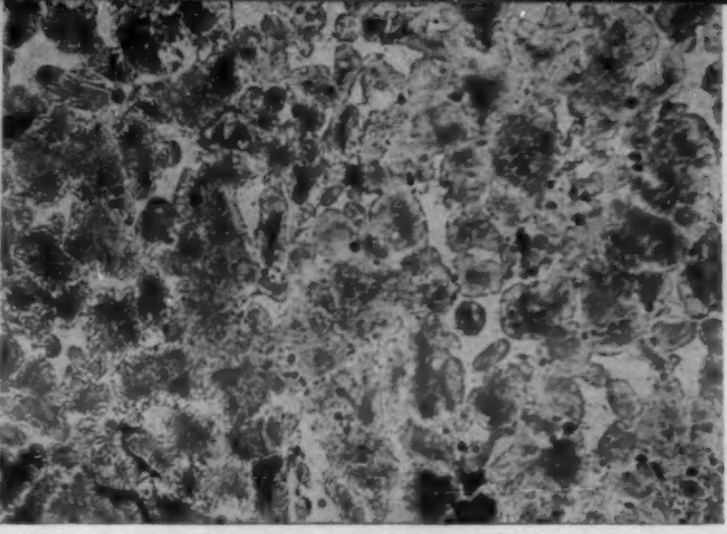


Fig. 2—Physical property ranges available with various basic materials and treatments of cemented steels. See accompanying Table for detailed data.

Material and General Treatment (after infiltration)	Heat Treatment Employed (time and temperature cycles)	Physical Properties Obtained		
		Tensile Strength, p.s.i.	Elongation, %	Hardness, Rockwell
Steel-copper; no heat treatment	Presintered, infiltrated, slow- or fast-cooled	70-100,000	7-2	B75-100
Steel-copper; case-carburized, quenched and tempered	Infiltrated; slow-cooled to room temp.; carburized at 1600-1750 F, quenched from 1500 F; tempered 1 hr. at 300 F	120-160,000	5-3	Core: C30-45 Case: C50-60
Steel-copper; combination steel-hardening and precipitation-hardening	Infiltrated; slow-cooled to room temp.; reheated to 1475 F, slow-cooled to room temp.; reheated to 1550 F, water-quenched, tempered 1 hr.	130-185,000	5-3	C30-45
Steel-copper; combination steel-hardening and precipitation-hardening	Infiltrated; slow-cooled to room temp.; reheated to 1475 F, slow-cooled to room temp.; reheated to 1550 F, water quenched, tempered 2 hrs. at 930 F	110-145,000	5-4	C25-35
Steel-copper; combination steel-hardening and precipitation-hardening	Infiltrated; slow-cooled to room temp.; reheated to 1475 F, slow-cooled to room temp.; reheated to 1550 F, water quenched, tempered 1 hr. at 1100 F	90-115,000	7-4	B90-100
Steel-copper; over-tempered and over-aged	Infiltrated; slow-cooled to room temp.; reheated to 1475 F, slow-cooled to room temp.; reheated 18 hrs. at 1200 F	80-90,000	12-8	B85-90
Iron-copper; no heat treatment	Infiltrated; slow-cooled to room temp.	50-75,000	12-6	B50-80
Iron-copper; case-carburized, quenched and tempered	Infiltrated; slow-cooled to room temp.; carburized at 1600-1750 F; quenched from 1550 F, tempered 1 hr. at 300 F	60-100,000	8-5	Core: B70-100 Case: C50-60
Iron-copper; precipitation-hardened	Infiltrated; slow-cooled to room temp.; reheated to 1475 F, slow-cooled to room temp.; reheated to 1550 F, water quenched, tempered 1 hr. at 600 F	60-125,000	8-3	B70-100
Iron-copper; precipitation-hardened	Infiltrated; slow-cooled to room temp.; reheated to 1475 F, slow-cooled to room temp.; reheated 2 hrs. at 930-1290 F	50-90,000	18-8	B55-90

Physical Properties Obtained with Specific Combinations of Sinteel "G" Materials and Heat Treatment. Some of these, especially the properties of the precipitation-hardened steel-copper materials, are exceptionally high for powder metallurgy products. (Molding pressures were 22 to 45 tons per sq. in. The "steel" structures were approximately eutectoid, with about 0.8% carbon.)



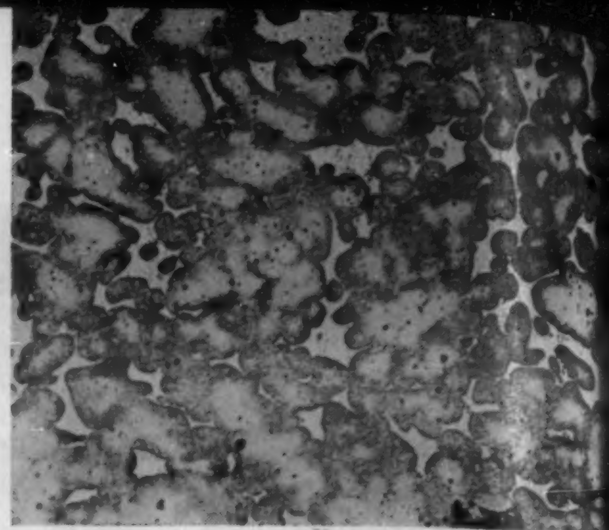


Fig. 3—Microstructures of steel cemented with copper alloy (85% steel, 15% copper alloy) by the Sinteel "G" process: (a) as-infiltrated, X200; (b) as-infiltrated, X1000, oil immersion; (c) heat-treated, X200.

cially as related to the materials and processing methods employed. In general the cemented *iron* products (that is, those not containing any carbon) exhibited tensile strength values in the neighborhood of 100,000 psi. and elongations around 6% after precipitation treatment. Several ranges of properties of the cemented steels, depending on the heat treatments given them are also reported, both in Fig. 2 and in the Table. The highest tensile values of steel-copper alloy structures are in the neighborhood of 175,000 psi., with 3 or 4% elongation, after a combination of steel-hardening and precipitation-hardening treatments.

A significant feature of these materials is that they are close to absolute density, and this high-density and accompanying high strength are obtained not by using high molding pressures but by infiltrating a low-pressure-molded compact. The virtual absence of porosity is evident in the accompanying photomicrographs. Actually the densities of products made by this method have never been lower than 7.8 grams/cc. with up to 35% copper alloy as infiltrant (which is another way of saying that the density has always been at least 96% of the absolute or "theoretical" density).

Their inherent brazeability and their better machinability as compared with porous products have been mentioned earlier. The cemented steels are also amenable to electroplating; their corrosion resistance seems comparable with that of ordinary steel, although long-time tests have yet to be carried out. Heat-treaters will also appreciate the fact that the copper coating on these cemented steel parts is an automatic "stop-off" against decarburization, so that their heat treatment is that much simpler.

With raw materials and infiltration practice under the necessary close control, dimensional tolerances can be held to ±0.002 or even ±0.001 per linear inch, and this without a coining or sizing operation after infiltration and heat treatment. For closer tolerances than these the conventional pressing and sintering of ordinary powder metallurgy materials, followed by coining and sizing would appear to the author to be better production practice. The surface appearances obtained in the Sinteel "G" process approximate those found on die castings or precision castings.

The optimum size range for products made of Sinteel "G" is from 3 oz. to 20 lb. In the larger sizes the material is economically more attractive than in the small sizes, because (1) press or die costs would be excessively high if a dense strong part were to be made by conventional high-pressure powder metallurgy methods, whereas cemented steel parts do not require high pressures and large presses for their production and (2) with Sinteel "G" the infiltration operation and its manipulation become increasingly more expensive on a *per-piece basis* as the size of the piece decreases; this stems from the constant cost of infiltration, which makes the relation of infiltration cost to total piece cost less favorable as the size of the piece decreases.

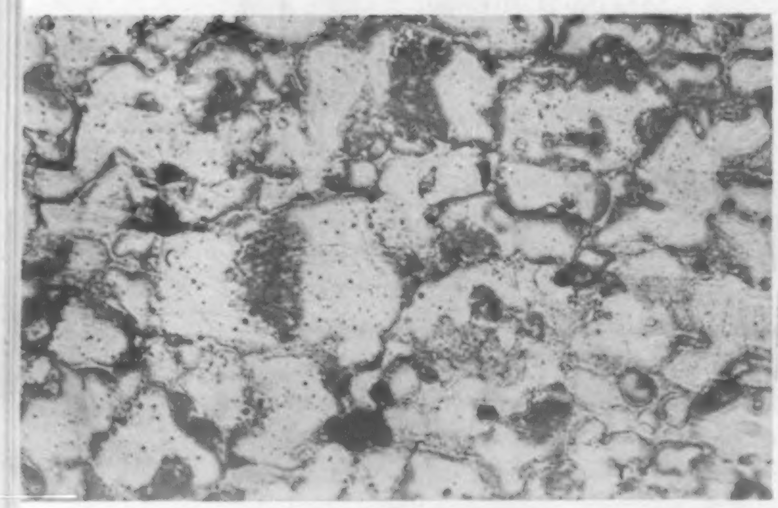


Fig. 4—Microstructure of iron cemented with copper alloy (85% iron, 15% copper alloy) by the Sinteel "G" process as-infiltrated (a) at 200 magnifications, (b) at 1000 magnifications, oil immersion. Both etched with picral. Note the small number of pores and the generally "solid" nature of the structure.

Fields of Use

Based on these characteristics, advantages and limitations and on certain already established applications, the general field of use for the cemented steels made by this process is for large, strong iron-base parts that are difficult or impossible to make by normal methods because of their requisite strength, size or complexity. Specifically, this field includes:

(1) Machine parts where the quantities required are sufficient to justify the use of powder metallurgy rather than casting and/or machining as a production method (although they need not always be "mass-production" in volume) and *especially* where the mechanical properties of the product are important. In addition to the high-production-volume jobs for which powder metallurgy traditionally has bid, this would include those relatively low-production-volume, high-strength-of-product situations for which powder metallurgy fabrication has previously been considered competitively unsuitable.

(2) Parts that are too large or too complex to be made by usual powder metallurgy methods (e.g. those with obstructions in two dimensions or those made up of two different, non-axial shapes such as the offset gear), but which can readily be manufactured using the self-brazing characteristics of Sinteel "G". The offset gear (center, Fig. 1) is an excellent example of a self-brazed cemented steel part that would be difficult to make by normal powder metal fabrication for no other reason than its high length-width ratio, but which is actually *impossible* to make by normal powder practice because the offsetting of the gear teeth would prevent removal of the part from the dies.

In applying the process to these very large or exceptionally complex parts surprisingly simple devices can be employed to provide mechanical interlocking where the latter is helpful. Fig. 5 is a diagram of another complicated part, and illustrates the technique of designing symmetrically matching sections that are simple to form, will fit together and be amenable to composite construction, yet which can be produced as identical metal powder pressings in the same die. The interlock devices are "naturals" for the powder metallurgy method, while the brazeability is inherent in the material. Other applications of this type are diagrammatically illustrated.

Thus we have a new powder metallurgy product that provides industry with a new type of material of fargoing possibilities. Full realization of these will depend on a number of factors (for example costs, parallel developments in other fabricating methods, etc.) which can be completely and accurately analyzed only after the passage of much time and the performance of many tests. Such tests are now underway, and continued investigation of the material, especially on the part of its users, will broaden its field and indicate the limitations on its utility.

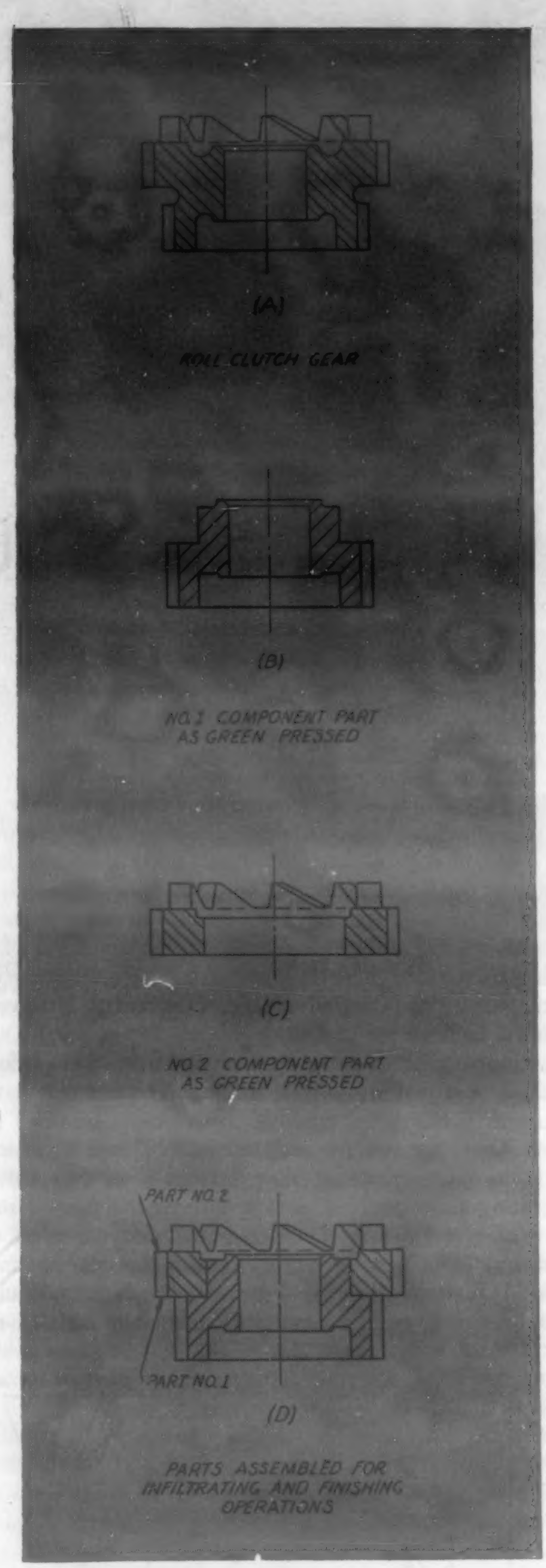


Fig. 5—The roll clutch gear shown here was originally designed as at (a). When made by the cemented steel process it was broken down into two separately pressed parts (b and c), then assembled and infiltrated to give a firmly brazed unit, shown in (d).

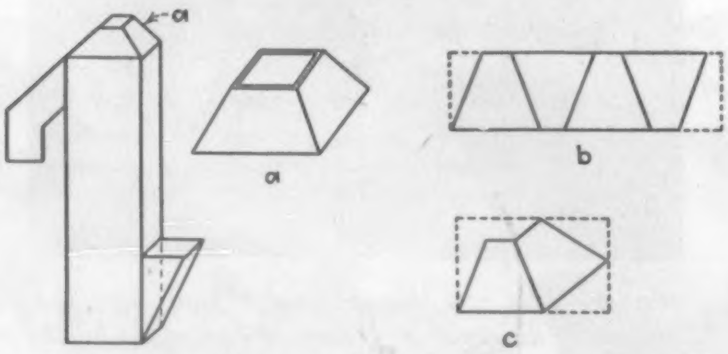
Proper welding procedure is important in fabricating stainless steel parts because of possible economies in time and savings in expensive materials

WELDING STAINLESS STEEL

Welding Stainless Steel . . . Part II

by C. C. HERMANN

WELDING SHOULD NOT replace bending where a bend can be made to advantage. The layout man will discover that many designers forget all about bending operations when making the design and if he is on his toes he will call attention to such oversight rather than proceed with the layout involving a long straight weld where a bend would perform the service to better advantage. Due regard, however, must be had for the stock waste. For example, an accompanying drawing shows a stainless steel bucket elevator which is a simple rectangular shape but having a frustum of a pyramid top section as shown at *A*. There are two methods shown at *B* and *C*, which the layout man could follow. That at *B* would involve cutting four sides and welding them together at the corners to produce the part, while that shown at *C* would involve a bend for two of the corners and welds for the other two. From the two layouts, it will be observed, that in example *B* the waste consists of a triangular piece at each end of the sheet while that shown in *C* involves waste at both ends of irregular shaped pieces, and without making any further calculations, the waste in method *C* far exceeds that of method *B*. It is then a matter to weigh the cost of waste of *C* in excess of the waste of *B* against the cost of two straight welds involved in *B*.



Here are two ways of making the same part. B *involves more welding, but is more economical of material.*

Design Dictates Fabrication Procedure

Analysis of the design must be made to determine the fabrication procedure. Certain sub-assemblies can usually be made to advantage and finally the entire structure assembled from the sub-assemblies. This method permits more than one welder working on the job at one time, in fact as many welders can be used as there are sub-assemblies; or it may result in economies being obtained through line assembly instead of ordinary job shop methods where a number of duplicate units are to be made. During the assembly whether sub-assembly methods are used or not, considerable time will be saved if the various pieces are clearly marked by the cutting department. The designer has shown numbers for each piece and if he has not done so then the layout man should assign numbers placing such numbers on the assembly drawing as well as on his cutting patterns and instructions. If sub-assemblies are involved all of the pieces of a given sub-assembly should be brought together and delivered to the fitter or welder as the case may be in packages as it were. Anything which will reduce confusion will pay dividends.

Certain assembly procedures must be worked out.

Spot welding is being used increasingly in joining stainless steel parts.

Depending on the type of structure and the accuracy involved, pieces cannot be manually held together and tack welded with any hope of producing a serviceable and accurate result. In many types of structure, it is necessary to actually produce holding fixtures to hold the different pieces together and in correct relation while welding. The cost of producing such holding fixtures, if they are something special and not ordinarily used, should be charged to the job. This results in additional costs and cannot be considered as ordinary overhead. The manufacturing accounts would not stand inflation to the extent of absorbing such unusual expense without adjustment of the overhead percentage.

Preparation costs should include the setting up of the structure by use of holding fixtures, special or otherwise, and not infrequently the taking down of same to make adjustments in clearances etc. Here we learn the importance of accuracy in layout and setting. For example if a joint is, say 1/16 in. wider than required the welding cost of that joint is going to be nearly 50% higher due to the extra welding rod used and the labor expended.

Emphasis should be given to the importance of holding jigs and fixtures as production cost reducing devices. The lowest cost weld is the down-hand weld, and a fixture which will position the structure for down-hand welding usually pays for itself in short order. For example, a plain right angle corner weld will cost 40 to 50% less when turned so that the welder can look directly down into the V instead of making a side weld out of the job by laying on the back of one of the plates. For repetitive production welding, jigs and fixtures have been produced which reduced the welding time in many instances by as much as 80%. Usually the use of jigs and fixtures for position welding involves sub-assembly welding. It was due to the adoption of this practice that such splendid showing was made in the construction of many war items and especially in ship construction.

Not infrequently a simple holding jig or fixture can be made which will pay for itself many times over in the production of a single unit and this should be carefully weighed by the designer and fabricator.

During the war years welders with experience on stainless steel were scarce and the shops found themselves faced with the problem of educating their men.

The type of welding equipment has much to do with the amount of work turned out. Some of the old equipment is inefficient, out of date, and out of service, too much of the time to make its use profitable. It was necessary, however, to bring into service every kind of machine which could produce a weld regardless of age and condition. The maintenance department fixed them up somehow and the shop made use of them mostly as school room equipment. Many shops claimed that there was a distinct advantage in using the older machines in their training courses in that the students then would be trained to do passable work on the old machine, and the officials knew that they would do much better on the better type of equipment. Regardless of that, it was a good use of the old equipment since a new number of welders were thus produced without taking new and usable machines out of regular service.

The best type of welder, in the author's opinion, is the motor generator set type, that is, a machine equipped with a d.c. generator to produce the necessary welding current and this generator driven by an a.c. motor taking its current from the plant service lines. In this manner a steady flow of current is assured without having to contend with the fluctuations in voltage in the shop power feeders. The size machine to purchase is determined entirely by the class of work to be done by the shop. The 200-amp. machine is a useful size machine and no welding shop can be complete without one or more of this size. The 300-amp. machine will handle most heavy jobs coming to the job shop.

In mild steel welding, considerable speed may be obtained by merely increasing the size of the electrode. This is not always possible when working with stainless steel. Experience tells us that the size of the electrode for a given thickness of sheet is quite well fixed—also that the type of electrode to avoid brittleness of the resulting weld is limited. Do not expect the shop to save time by going to heavier current values or larger size rod when welding stainless. Too much heat will merely result in more grinding and polishing to eliminate spatter and discoloration.

Small Beads Most Efficient

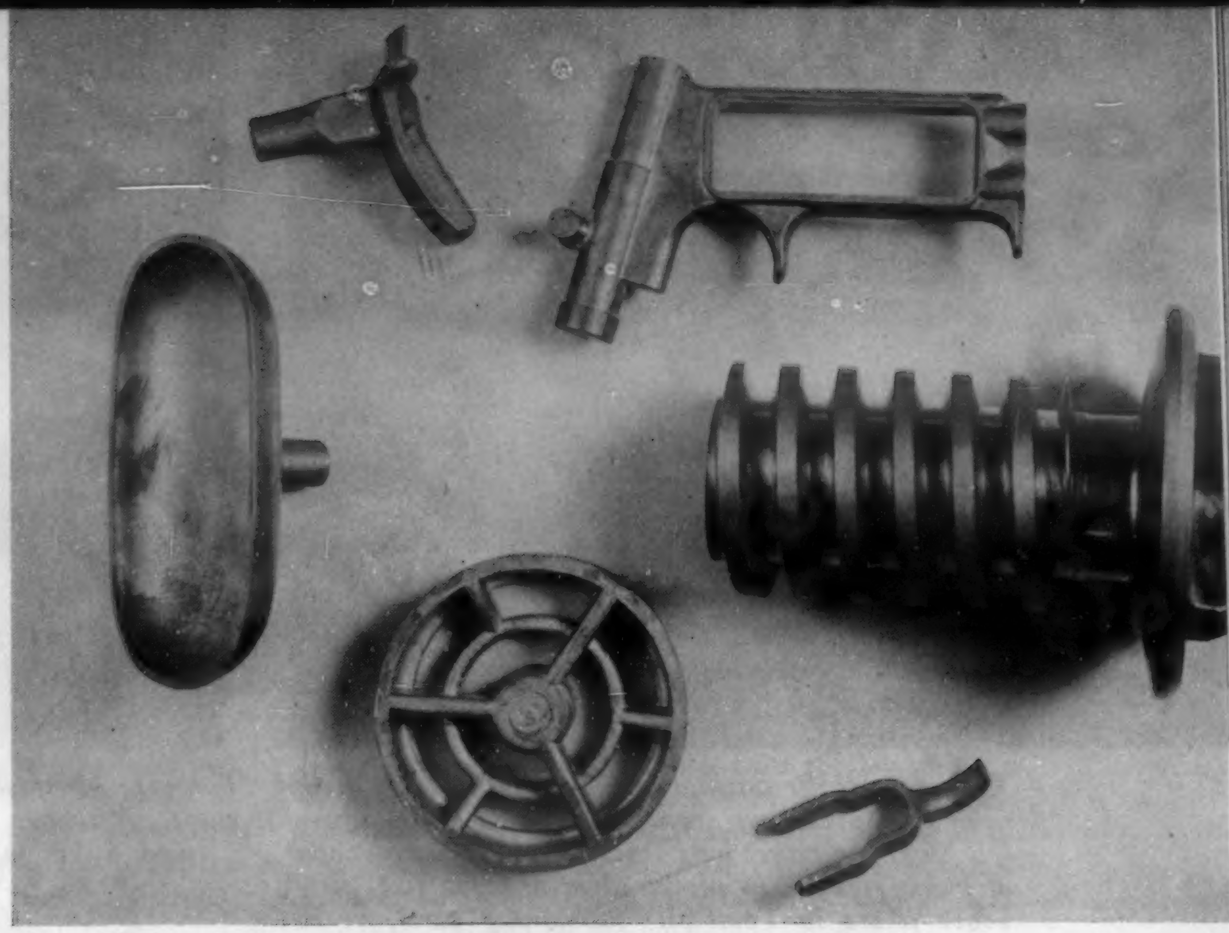
The most efficient weld is obtained by laying a small bead down and then laying another and another over this until the weld is complete. No weaving should be used and the slag should be removed completely from each before another is applied.

Cleaning of parts after welding may or it may not be classed as a production job involving direct labor depending on the practice of the shop in question. Correctly it is just as essential to the work quality as a coat of paint and therefore it is direct labor, however, a short cut to quality cleaning of broad surfaces without grinding is via abrasive blasting equipment. The actual time required for cleaning by this method is less than 25% of that required by pickling and polishing although some exacting work is polished following sand blasting.

The war brought about a considerable number of jobs to be made of stainless steel to be spot welded. Spot welding was, of course, developed in the mild steel range of industries for production welding. Such items as did not require gas or liquid tightness were spot welded. For example, such items as gas and electric ranges, all kinds of household furniture, desks, filing cabinets, etc., are fabricated by spot welding methods. Spot welding involves melting and fusing the base metal by bringing the electrodes together with the work between them. Sufficient pressure is exerted on the points to press the work sheets together firmly while passage of the current through the work produces the necessary heat. Due to the lower thermal conductivity of stainless steel less heat is conducted away from the contact point and therefore, actually less energy is used to produce a sound weld than when working with mild steel. The metal surrounding the spot weld will be discolored slightly and as with arc welding this fault is removed by pickling and polishing when necessary.

Mechanical strength of the spot weld is calculated on the basis of the area of contact metal actually fused. Obviously the joint is not designed for heavy loading, stainless steel being selected to resist corrosion rather than to sustain heavy loads. To form the box-like devices shown bending of the sheets is resorted to in order to produce a flange looking outward from the body to permit spot welding procedure.

A combination of ribbing strips of stainless steel and spot welding them to sheets as stiffners may also be used for reinforcing vessels designed to hold liquids and gases. This system of reinforcing may be preferable to that of composite material reinforcing and will prove more economical of material than specifying heavy sheets for the job. For example, tanks can be made of rolled sheets in the usual manner but before assembly the rolled and formed rib strips can be spot welded around the sections supplying the cylindrical reinforcing needed. Also vertical reinforcing ribs can be added in the same manner. Thus very thin material can be used to provide resistance against corrosion and the mechanical strength to withstand the loading is procured by reinforcing. Considerable reduction in weight of finished product is obtained and a lower manufacturing cost results.



Brass forgings typical of those produced by Titan Metal Mfg. Co. in medium sizes. Flash has been removed from all the parts and the web in holes has been sheared out. The largest part has been machined.

PARTS ENGINEERING
BRASS

Brass Press Forgings or Die Castings—Which?

by HERBERT CHASE

TITAN METAL MANUFACTURING Company is one of the world's largest producers of brass forgings as well as of brass die castings; thus its engineers and metallurgists qualify as experienced judges as to the relative merits and limitations of the two classes of products. Observations as here recorded are based largely on their experience and relate, of course, to the types of product there manufactured.

In this company's plants, all forgings are produced in presses of which several types are used. The die castings are made chiefly in Polak machines from semi-molten metal but some are now produced from molten (liquid) brass on a Lester machine. Comments given, although based on the experience mentioned, apply in general to brass forging and die casting practice. No split forging dies are used and this precludes making odd shapes of forgings that could be pressed if such dies were applied.

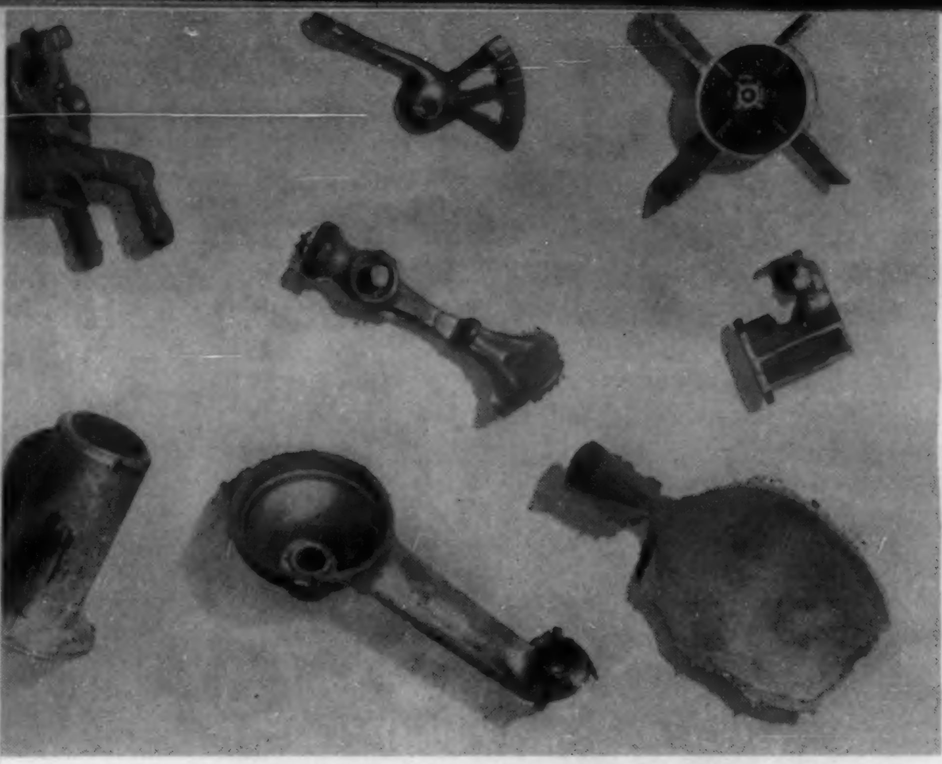
With the exception of alloys, which are quite similar, many design and physical factors affect the choice of method for producing brass parts.

In choosing between die cast and forged brass or bronze parts, it is well to remember that die castings, in common with all other castings, are subject to some porosity and have a crystalline structure more or less typical of other cast parts, although chilling is more rapid than in castings made in nonmetallic molds. Forgings, on the other hand, have the dense structure of wrought parts, the metal having been extruded before again being hot-worked into forgings. Thus the metal is denser, stronger and more ductile than in castings, hence a lower factor of safety can be used.

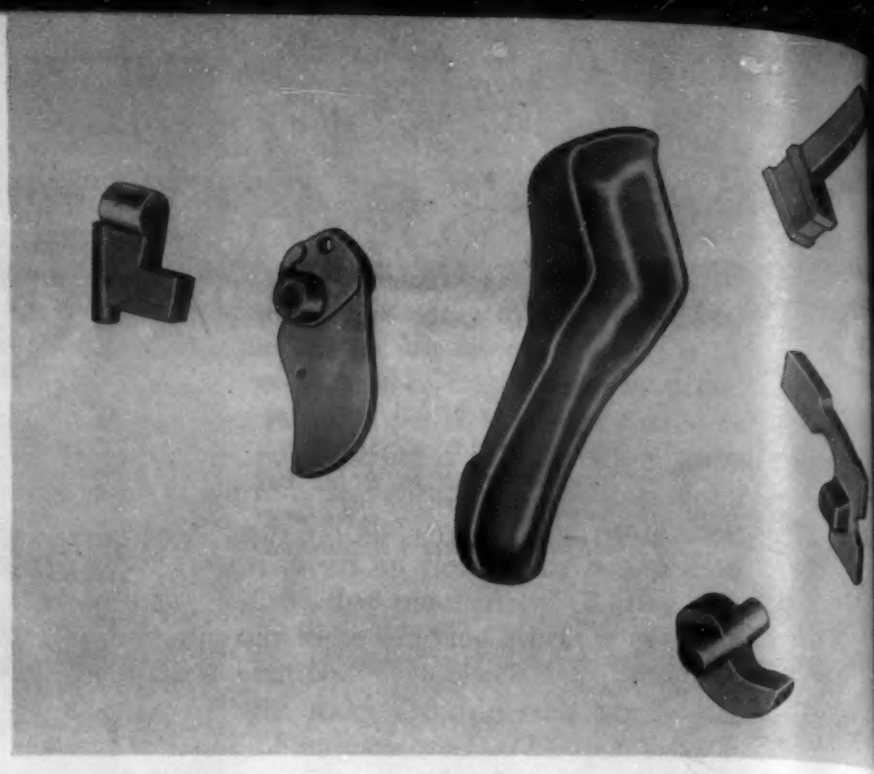
As against this, the casting requires much less processing, for the metal is converted directly from molten to final solid state in one operation, namely casting.

In forging, the metal is first cast into billets which are cut when cold, reheated, extruded into bars or shapes, cooled, cut into forging blanks, reheated to forging temperature and finally forged. This makes the forging basically more expensive but many other factors enter into individual cases so that the net cost usually favors the forging.

Quality also has to be considered as do, too certain



Typical brass die castings as they appear before flash removal. Some have cored holes, the parts at lower left requiring rather long cores. The ice cream spoon at lower right is in nickel silver and the two parts above it are in Tombasil. Remaining parts are in yellow brass.



Forgings of small size in yellow brass are readily made in shapes such as these. Some have bosses formed by metal that is forced into die recesses.

manufacturing exigencies and limitations, so that, for parts that can be made either by die casting or forging, the latter may have to be chosen even though sometimes less economical. Some parts that are forged cannot be die cast in acceptable form but it is also true that some die castings cannot be produced by forging. For reasons such as these, each case has to be considered on its merits, the choice depending upon which offers the better over-all results after both cost and quality are given due attention.

Total cost naturally requires study of such considerations as tooling (including die construction and maintenance) machining and, in certain cases, even the expense of a satisfactory applied finish. In consequence, the choice seldom is a simple "open and shut proposition" it demands a careful weighing of many factors, most of which are mentioned under subsequent headings.

Size and Weight

Maximum size and weight are determined largely by the capacity of equipment available. In die casting, the size must be within that of a die that will fit one of the machines available. Castings having a maximum projected area of 70 sq. in. can be handled and the maximum dimension should not exceed 24 in. The theoretical maximum weight limit is 11 lb. but the practical limit (not thus far exceeded) is 9 lb. There is no known minimum limit on size or weight for either die casting or forging, both having been produced down to a fraction of an ounce and in fractional inch dimensions.

For forgings, a maximum weight of 100 lb. can be attained on the largest (2500-ton) press now installed but the maximum weight thus far called for has been 30 lb. Forging dies up to 30 x 30 in. can be accomplished.

Density and Grain Structure

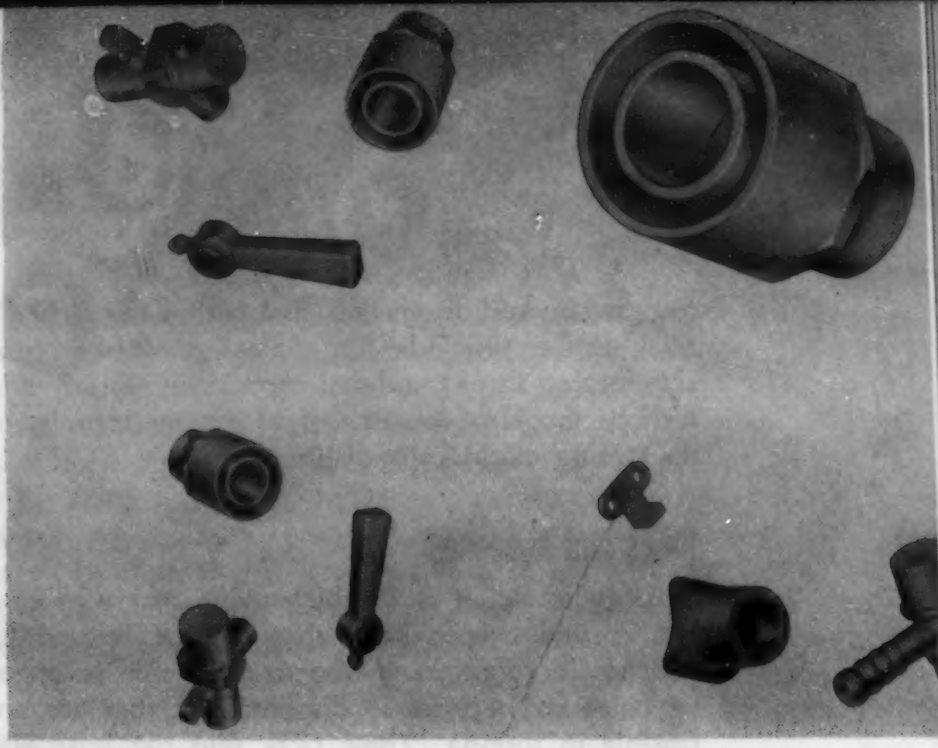
Where maximum density is required, the close-grained structure of the forging is clearly indicated. Die castings not only have a more open grain but are subject to some porosity, largely because at least a small amount of air invariable is trapped in the die however well gated and vented it may be. It is possible to minimize porosity by close control and usually to confine it to areas where it is of little or no significance but still not equal the forging. Consequently, the latter is usually recommended for parts subject to high gas or liquid pressure, unless the part is one that cannot be forged. In the latter event, the die casting can be checked for possible leakage under high pressure, preferably after machining, and leakers scrapped, although this naturally increases costs.

Good forging practice makes it possible to control flow lines in the forged part and to produce a flow line pattern that is favorable to maximum strength and to minimum chance of fatigue failure in the part. Corresponding results are not attained in casting.

Physical Properties

Since most physical properties are measured on specimens that are die cast or forged separately from most parts produced by these means, the precise values attained have a somewhat unpredictable relation to those applying in the parts themselves. There is little doubt, however, that forged parts are superior in tensile and yield strength as well as in ductility and reduction in area to parts die cast in equivalent

Compass frame, typewriter levers and other die cast parts here shown are in yellow brass. The piston at upper right has a forged brass flange (shown separately at lower right) which is used as an insert in making the die cast shank one end of which shrinks around the grooved boss of the forging.



Brass forgings, some of which have recesses formed by a solid punch in the center of a second punch with a tubular end that is concentric with the solid punch and forms an annular recess around the central boss. Other parts shown include valve handles with serrations formed in the hole.

alloys. Die cast parts, however, are likely to have greater hardness and superior bearing properties. But such differences as exist are usually not great enough to justify a choice when taken alone. It is probable, on the other hand, that, where stresses are high, the forging may be the better choice. As the chances of flaws are less in the forging, the use of a somewhat lower factor or safety is indicated when it is chosen.

Complexity in Design

Where a part must be of a rather complex shape, the chances favor its production by die casting rather than forging. In any event, many parts too complex to forge in a given shape can be die cast successfully. This is true chiefly because considerable coring that can be done in die casting cannot be done in forging and because casting dies can be equipped with slides not feasible in forging. In forging, if holes are produced they must be made by punches of substantial proportions and having axes parallel to die motion. But in die casting, side holes or those at odd angles can be made by cores. These can be more slender and longer than forging punches. Clearly then, die casting has an advantage in that parts can be more complex in shape.

Production Rates and Labor Costs

In respect to production rates, the forging sometimes has an advantage. But if the part is small and is required in such volume that casting dies with multiple cavities become feasible, the die casting rate may be higher. For die casting in brass, the usual rate is from 100 to 200 cycles an hour.

Only in unusual cases does the forging rate fall to 100 per hour, and, especially for small forgings, it can exceed 1200 an hour. An average rate of 200 to 400 forging cycles an hour is attainable, but including furnace tenders and a separate man handling ejected forgings, 1½ to 3 men per press are commonly needed. On an average, however, the forging rate alone probably is higher but, when the supplementary and preliminary operations (including production and cutting of extruded bars) are considered, total labor per forging probably exceeds that per die casting.

Occasionally, multiple-cavity forging dies can be used but they cannot have so many cavities (12 or more) as are feasible in die casting small parts needed in large volume. Including such cases and considering the greater number of operations in forging, the die casting appears to have an edge on over-all production rates, although the output per forging press probably exceeds that per die casting machine.

Section Thickness

Sections producible in brass die castings can be much thinner than in forgings provided, of course, that adequate strength is attained. In general, sections as thin as 0.070-in. can be die cast, if not over too large an area, while, with forgings, 3/32-in. walls are about the minimum generally feasible and then usually not over a very large area.

Although thick sections (½-in. or more) can be die cast, such sections are not favorable, as they tend to raise die temperatures and increase die deterioration, besides lowering casting rates. Reasonably thick sections are considered favorable in forging, as they commonly involve less metal flow and the temperatures in the die are well below those in casting. It

can thus be said, in general, that parts having chiefly thick sections should be forged (unless not of a favorable forging shape) and that parts having mostly thin sections should be die cast, if within the capacity of the casting machines available.

Holes and Recesses

As indicated, it is feasible in die casting to core smaller and deeper holes than can be formed by punches in forging and also to form side or angular holes and recesses so disposed that they are not feasible in forging. These facts, plus the feasibility of slides in the die, make it possible to produce by die casting many hollow and deeply recessed parts that cannot be forged with corresponding holes and recesses.

In die casting, molten metal is forced or gated around cores and fuses to form solid sections in a way not feasible at forging temperatures. The forging punch must not only have its axis parallel to die motion but must displace solid metal that has to be forced around the punch. Walls formed around punches in this manner seldom can be less than ⅛-in. thick and punches less than ½-in. dia. or more than double their diameter in length are usually too fragile to be feasible in forging. Hollow punches can be used if sufficiently sturdy and the hole they produce is not too deep.

Although cores in casting dies must also be sturdy, they can be smaller and longer than forging punches. As they often run at red heat, however, deterioration is rapid and provision for comparatively frequent replacement is necessary, especially where close limits are specified.

Working Temperatures

Since, in die casting, the metal must be partly or completely molten as it enters the die, it must be at a higher temperature than for forging, since forging slugs are always solid, though in a plastic condition. In consequence, the casting die, even though water-cooled, attains a surface temperature well above that of the forging die.

This makes for rapid deterioration of casting dies, even though they are made of refractory steel. Oxides collect on die surfaces and must be removed quite often, and gradual heat checking occurs. Cracks formed by checking result in rough castings and increase in depth too rapidly to be removed by re-dressing the die or core surfaces, especially where close dimensional limits must be attained.

Forging dies also deteriorate but heat checking, if it occurs, is less rapid and die life is likely to be longer than for an equivalent casting die. In both casting and forging dies, allowance for maintenance costs have to be made in figuring product cost but the charge for casting dies is higher.

Degree of Smoothness

Surface conditions in dies, both for casting and for forging, are substantially reproduced in the products they turn out. It follows that, as casting die surfaces deteriorate more rapidly (and also collect more oxide) forgings are superior in surface smoothness, in average cases, than die castings are. Moreover, die castings, being worked at higher temperature, have more scale. This too detracts from smoothness, leaving all advantage on this score to the forging.

Tooling Costs

Rough estimates place the average cost of forging dies at or about one third that for substantially equivalent casting dies even though, with the former, the cost of an extrusion die be added (as it should be when a special extruded shape, often used in forging, is employed). This estimate, of course, is only an approximation but is regarded sufficiently close as such.

Other tooling, as for flash removal, is about the same, for although the forging may require more metal removal in machining, the scale on the die casting is likely to be harder on tools. Holes that are cored in the die casting but are not made in the forging may increase drilling costs in the forging (or necessitate broaching if holes are not circular) but the easier machining on the forging offsets this at least in some degree. This commonly leaves total tool costs in favor of forgings.

Dimensional Tolerances

Die castings can be held, as a rule, within somewhat closer dimensional limits than forgings. The usual limits on die castings are ± 0.008 in. per in. as between points formed by solid portions of the die. As cores wear and oxides build up on die surfaces, redressing of the die is required and there are corresponding changes in the size of the castings even though the above limits are commonly held when specifications require. Costs can sometimes be reduced, however, where wider limits are permitted.

In forgings, the usual maximum tolerance is ± 0.010 in. but this can be reduced to ± 0.005 in. per in. for certain dimensions, if required. Measurements across the die parting should allow somewhat greater tolerances. An accompanying sketch and table give the commercial tolerances adopted by The Brass Forging Association. In certain cases, forgings are planished, either hot or cold, to hold critical dimensions between closer limits, but this adds an extra operation and increases costs, though it may save a subsequent machining operation.

For die casting in brass, draft on cores and side walls usually is from 1 to 7-deg., although there are cases, especially where the casting shrinks away from the die wall, that less draft can be used. It is best,

however, to allow greater draft when conditions permit, as core and die wall wear can be reduced and easier ejection results, possibly avoiding some tendency to distort or mar castings by permitting less pressure on ejector pins.

A draft of 1 to 5-deg. is commonly needed on brass forgings although, on shallow cavities and short punches, slightly less than a 1-deg. taper is feasible.

Flash Thickness and Location

On die castings, the flash has to be comparatively thin, as dies are locked under extremely high pressure and only enough clearance is left for venting, since spitting of hot metal must be avoided. Some flash occurs at core clearances and slide partings but it, too, is quite thin.

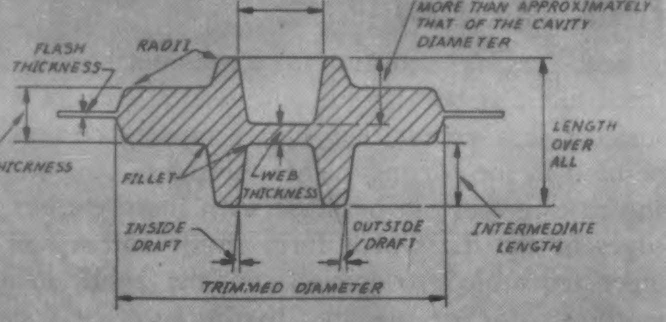
In forging, however, flash is thicker, for there is considerable flow of metal along the parting and this flow is considered essential to insure proper filling of the die and freedom from flaws in the forging. Despite the thicker flash, it is not considered harder to remove than that on die castings as the latter involves some scale that is hard on tools. The thicker flash results, however, in a more prominent flash line on forgings than on die castings.

In both die castings and forgings, flat die partings are preferred but stepped or irregular partings are sometimes needed. For forging, any side bosses must have their axes in the parting, even if it be made irregular to bring the axis into the parting, as no side projections that involve undercuts are permitted (unless split dies, not used in this shop are employed).

Although undercuts in die castings are preferably avoided because of higher die cost, they can be employed, often with a large saving in metal in the die casting, by employing one or more slides that are withdrawn as the die opens, to permit ejection of the casting. This as already indicated, is one factor that permits casting more complex parts than can be forged. If, as an alternative, the part is forged without an undercut, the forging is heavier or necessitates more machining to remove extra metal.

Scrap Losses

In general, scrap losses resulting from defective parts run from 7 to 10% in brass die castings as against 3 to 5% in brass forgings. For each gate of die castings there is also a slug, sprue and runner to be remelted along with some thin flash. With forg-



Tolerances given below are those suggested for use. Actual tolerances obtainable depend largely on details of the forging involved.

Standard Min. Nonferrous Forging Tolerances

		Regular Brass	Naval Brass	Aluminum Silicon Bronze	Copper
Draft—Outside[1]	Hammer forgings Press forgings	3° to 7° 1° to 5°	3° to 7° 1° to 5°	3° to 7° 1° to 5°	3° to 7° 1° to 5°
Fillet and Radii[2]		1/8"	1/8"	1/8"	1/8"
Tolerances: Dimensions[3] and Diameter	Up to 1" incl. Over 1" to 2" incl. Over 2" to 4" incl. Over 4" to 6" incl. Over 6"	±.005" ±.008" ±.010" ±.015" ±.031"	±.005" ±.008" ±.010" ±.015" ±.031"	±.007" ±.010" ±.015" ±.020" ±.03125"	±.007" ±.010" ±.015" ±.020" ±.03125"
Flash Thickness		.035"	.045"	.080"	.080"
Web Thickness		3/32"	1/8"	1/4"	1/4"
Flatness per Inch		.005"	.005"	.005"	.005"

NOTES: [1] Inside draft will be somewhat greater than outside draft.
[2] Radius shown is minimum desirable for maximum die life, but fillets of very small radii can sometimes be made.
[3] A minimum of ±.007" tolerance should be allowed for all dimensions affected by the parting line of the forging.

Ordinarily a minimum of 1/32" should be added to all surfaces which are to be machined.

ings, there is the heavier flash to cut off and remelt as well as the losses in making and sawing extrusions. When, as in this plant which makes the extrusions, this scrap is remelted and reused without resale or shipment, the trimming and remelting losses are moderate. In the die casting process, gates, sprues, slugs, flash and machining chips go directly back to the melting furnaces so that net scrap loss is quite low.

Inserts

Inserts, either of brass or of other metal, can be used in making brass die castings, although such use slows the casting cycle and thus reduces casting rates. With inserts, however, it is possible to accomplish results not attainable by other means and thus to extend the utility of the die casting. In at least one important application, a brass forging is used as an insert in making a brass die casting, yielding a composite product not producible at equal cost by other means. Inserts are not feasible in making forged parts but forgings (as well as die castings) can be provided, of course, with inserts pressed or screwed in after machining.

Fillets, Corners and Threads

Both forgings and die castings should have at least small fillets at both inside and outside corners where surfaces join except that square outside corners can be used in the parting plane. Although both forging and casting dies can be made with sharp corners, the edges of the die which form inside corners on the piece are subject to erosion and may result in flaws in the casting or forging. In the latter, too, better flow lines are produced at a fillet and, in the die casting, flaws may occur at sharp inside corners.

It is possible, however, to produce the U.S. Standard or rounded contour male threads on die castings, as cast, if threads are not too fine (say not less than 10 per in.), provided that the die is parted in the thread axis. This is not feasible in forgings, as forged, but, of course, both male and female threads can be cut either in die cast or forged parts. Die cast threads are likely to require chasing for close fits and it may cost little, if any more to chase a thread not cast than one formed by the casting die, especially as the latter is subject to rather rapid deterioration.

Teeth, Serrations and Lettering

Gear teeth of a shape that will clear the die can be produced on brass die castings but may require shaving if close limits must be held. Serrations and splines can also be formed provided sufficient draft is allowed.

Letters, parts numbers, trade marks and flat knurling are produced on both forgings and die castings but generally are confined to surfaces parallel to partings. In general, it is better to recess the letters in the die (so that they are raised on the forging or casting) as the recessing costs less than raised letters in the die and raised die letters are subject to more rapid wear. In the forging, lettering should be so placed as not to interfere with the flow of metal in the die.

Alloys Available

As indicated in the accompanying table, the alloys commonly used for forging and die casting are quite similar or identical. It is possible to die cast almost any brass or bronze but, the higher the melting point, the shorter is die life. Common yellow brass is most often used in brass die casting, as its cost is lowest as secondary metals can be applied. The silicon alloys have a somewhat lower melting point and are quite fluid (which is an advantage in complex castings) and have high strength. Their cost is a little higher, however, and they are harder to machine than yellow and red brass. Alloys high in nickel have a silvery color, are strong and high in corrosive resistance, sometimes being used where a light color without plating is desired.

Although a considerable range of forging alloys is available, they must be of a type that can be extruded and that will also yield the required flow in the die at forging temperature. Yellow brass accounts for the largest tonnage used in brass forging (for the same reason as in die casting) and produces excellent forgings. The other forging alloys listed are used mostly for special purposes, particularly where specific types of high corrosion resistance are required or where strength superior to that in yellow brass is needed.

Machinability

Brass forgings are generally considered much easier to machine than brass die castings although good standards for comparison of machinability are lacking. Die castings commonly have some scale that is hard on tools and the metal itself is harder than the same alloy in forged form. Machining of brass die castings commonly requires carbide tools, or makes them more economical. Brass forgings have little or no scale and, especially in yellow brass, are rated as free machining.

Conclusion

Other bases for comparisons of brass die cast and forged parts are occasionally applied but the above items are most frequently used. Details of design or application often dictate which shall be used but, where either is applicable, study of foregoing factors will usually enable a choice based on the preponderance of favorable factors that apply.

Composition and Properties

	BRASS DIE CASTING ALLOYS					BRASS FORGING ALLOYS								
	Yellow Brass	Red-aloy	Tombasil	Nickel Silver Tinicosil No. 20	Silicon Brass Eclipsaloy 10	Yellow Brass ASTM-B-124-44 No. 2	Naval Brass Navy Spec. 46-B-6-Int	Leaded Naval Brass ASTM-B-21-44 Grade B	Red-aloy	Nickel Silver Tinicosil No. 53	Manganese Bronze 46-B-15 Class A	Manganese Bronze AMS 4619	Alumi-num Bronze	Munz Metal
Composition (nominal) Copper	62	53	80 - 82	46	63 - 66	58.5 - 60.5	60	60	54	46	59	58	Balance	60
Silicon	—	—	3.5 - 4.5		0.75 - 1.25								1.6 - 2.5	
Lead	1	—	—	1.5	0.50 max.	1.5 - 2.5		0.80	3.0					
Tin	0.5	0.5	—	—	—		0.75	0.75			0.75			
Nickel	—		—	16						10				
Iron	—	1	—	1.5	—						1.00	1		
Manganese	—	—	—	—	—						0.40	0.50 max.		
Aluminum	—	—	—	—	—							1	6.5 - 80	
Zinc	Balance	Balance	Balance	Balance	Balance	Balance	Balance	Balance	Balance	Balance	Balance	Balance	—	40
Tensile Strength psi.	58,000		85,000	85,000	70,000	57,000	60,000	60,000		98,000	68,000	70,000	90,000	54,000
Yield Strength psi.	36,000		50,000	65,000	35,000	32,000	28,000	30,000		65,000		30,000	45,000	27,000
Compressive Strength psi.						85,000								
Shearing Strength psi.						55,000								
% Elongation in 2. in.	6.2		8.0	15.0	22	32	40	40		22	33	20	30	50
Reduction of Area, %	7.6		10 - 15	10 - 18		33					70		85	
Rockwell Hardness B	45					55 - 60	55	55			130			
Brinell Hardness	120 - 130		170	160	120	94								
Melting Point deg. F.			1575	1675		1620								
Specific Gravity	8.5		8.3	8.45	8.6	8.40								

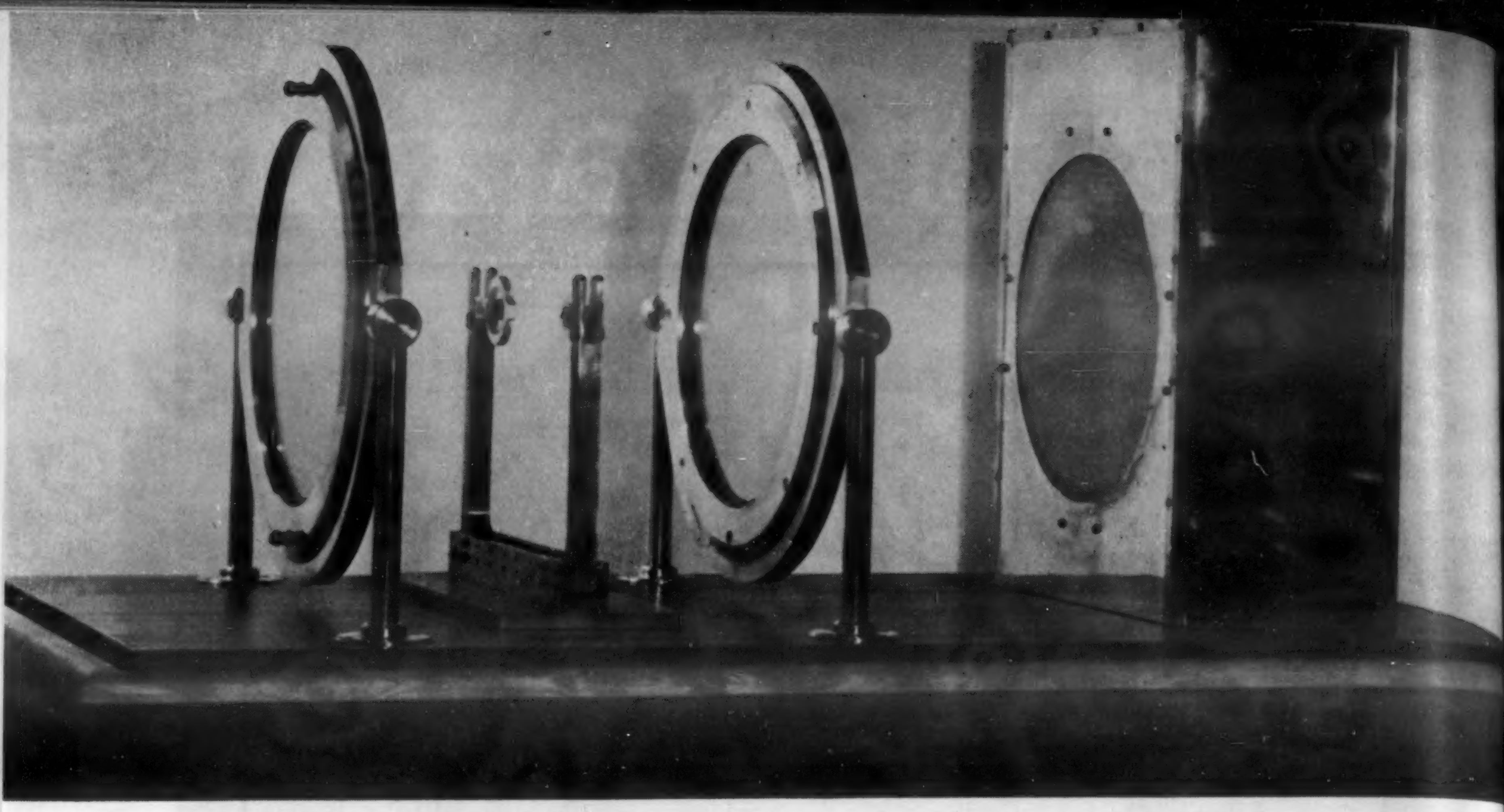


Fig. 1—A typical polariscope used for studying stressed photoelastic models.

TESTING

Stress Analysis Methods—

Choice Determined by Part's Design and Application

by W. M. MURRAY, *Massachusetts Institute of Technology*

This article is based on a paper presented at the recent annual meeting of the Meehanite Research Institute.

IN THE DESIGN of metal parts and structures careful stress analysis is often a very useful guide in arriving at the final design. The main object of such an analysis is to determine as precisely as possible the actual stresses and their distribution prevailing in a design under service conditions. In a great many cases the use of stress analysis enables a more economic design; by proportioning the structure properly in accordance with the stress distribution a general reduction in weight can often be accomplished.

A number of different methods for stress analysis are available. The analytical method, which utilizes mathematical formulas and equations for determining the stresses, can be applied for solving stress problems involving simple shapes. However, it is not practicable for calculating stresses on a complicated design. Another method, destructive testing, requires the part to be subjected to definite testing conditions until failure occurs. The type and location of the failure are examined and the part is redesigned, if necessary, in order to avoid a similar occurrence. In those industries where parts are made in large quantities the method has very definite application and in the long run will probably be the most economical. On the other hand the method of destruc-

Use of stress analysis in the early stages of product design will often result in a reduction in material and processing costs and in better parts.

tive testing is not at all desirable where only a few large units are to be manufactured.

For those design problems which require more information than that afforded by mathematical calculation, and which at the same time are inapplicable to the method of destructive testing, a different variety of analysis, termed experimental stress analysis, has been developed and is now widely used. Although there are a large number of experimental techniques which can be applied in determining stress distributions, most of them may be grouped under three general methods—photoelasticity, strain gage analysis, and stresscoat or brittle lacquer analysis. These three methods will be described in some detail in this article.

Photoelastic Stress Testing

The possibility of using the photoelastic method for studying stresses was recognized about one hundred and twenty-five years ago, but very little progress was made with it until about the close of the last century. Almost all the engineering applications of this method have been made in the last forty-five years and particularly following the development of the synthetic resins and Polaroid. Now the techniques and procedures are well known and the apparatus is so simple to construct that even the smallest engineering office has an opportunity to take advantage of its application. Fig. 1 shows a convenient type of polariscope in which the polarizing devices are Polaroid disks 12 in. in diam. This instrument can be used for visual observation or for photographic recording if a camera is set up to take a picture of the image of the model.

In the photoelastic method, models are made of some suitable transparent material and examined in polarized light. These models upon being subjected to stress show beautiful colored patterns when white light from an electric light bulb is used or black lined diagrams when a green or red light is used. An idea as to the appearance of a stressed photoelastic model in the polariscope can be obtained from Fig. 2 which illustrates the stress pattern found in a double ended eye bar subjected to tension. The black lines in the picture of the stressed model are called isochromatics. Each line represents a constant value of stress. Actually, the photoelastic stress diagram is like a contour map on which the lines of constant elevation are drawn. In the stress diagram the black lines represent constant stress levels and the change in stress from one line to the next is a constant for all lines.

It is evident that two kinds of information can be gained from photoelastic stress diagrams. One, the pattern of the stresses occurring in a structure can be studied and even from a very rough visual obervation the locations of highest stress may be determined by noticing the regions in which the isochromatics are crowded closest together. Second, the magnitude of the stress at any point can be determined by merely counting the number of isochromatic lines from a reference point to the point at which it is desired to compute the stress. It is necessary, of course, to calibrate the model material so that the stress magnitude corresponding to each one of the lines can be evaluated.

Because of its ability to determine stress patterns as well as the magnitude of the stresses in transparent models of metal forms, the photoelastic method has a number of very useful applications. One of these is its ability to bridge the gap between the mathematical theories and the actual conditions prevailing in the structure. If, for example, there is some member which is fairly regular and for which there can be applied a mathematical solution, except in some special regions, then, with the aid of photoelasticity, the stress concentration factor can be determined. This is the factor which is multiplied by the theoretically computed maximum stress in order to determine the actual maximum value. It is merely a ratio and can be applied conveniently after it has been determined by means of an experimental study.

Fig. 3 shows an actual case of this kind. The cantilever beam is quite regular, and, as such, can be easily subjected to a mathematical analysis of the stress along the edge of the beam except in the region of the fillet, where the formula does not apply, because the conditions at this location in the beam do not conform to the limitations and assumptions upon

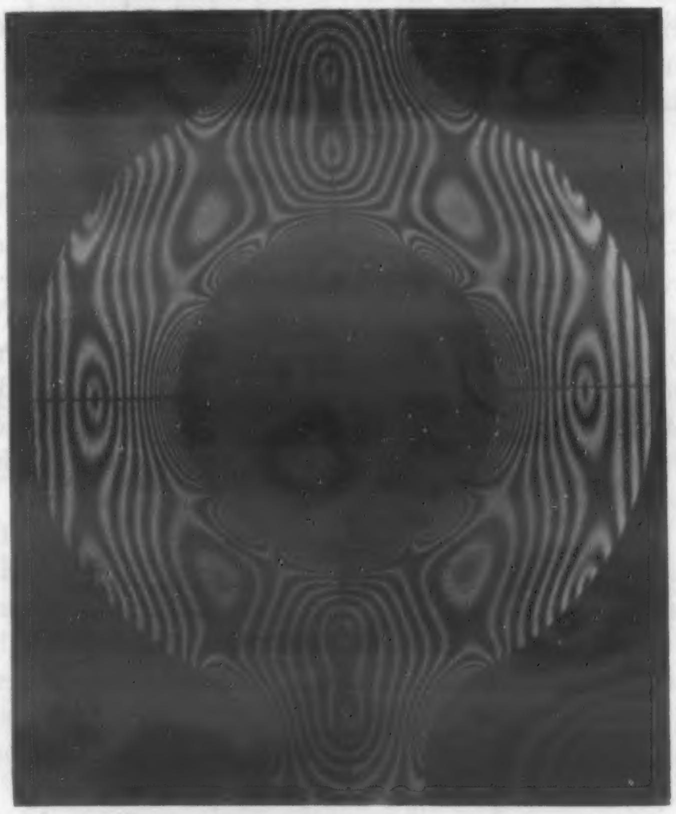


Fig. 2—A photoelastic stress pattern of a double ended eye bar in tension.

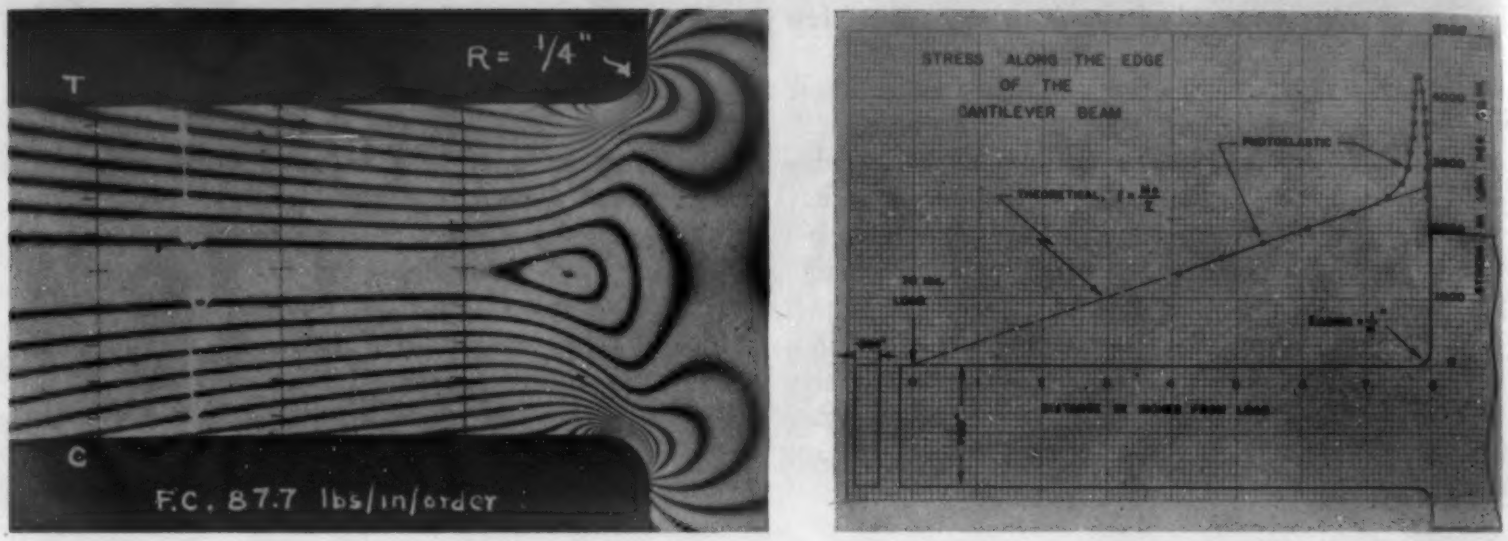


Fig. 3—Stress analysis of a cantilever beam. A shows the photoelastic stress pattern. B is a stress diagram showing the stress along the edge of the beam as determined by mathematical analysis and by the photoelastic method.

which the theory was developed. An examination of the stress diagram shows that the theoretical calculations take no account of the presence of the fillet whereas the experimental investigation shows a tremendous increase in the stress at the change in section. The actual peak stress values found for this particular condition are 4350 psi. by photoelasticity and 2700 psi. according to theory.

The ratio of these two values (approximately 1.6 in this case) is defined as the stress concentration factor. Fortunately, tables and charts of stress concentration factors for a wide variety of conditions are now available, and the designer can calculate his peak theoretical value with a simple formula and then multiply by the stress concentration factor to obtain the actual value which is expected to prevail.

Fig. 3 also gives an idea as to the reliability of the photoelastic method. In this diagram the photoelastic values obtained have been plotted as dots and the corresponding theoretical distribution is represented by the dashed line. From the close agreement (except in the region of the fillet where the theoretical determination does not apply) between these experimental and theoretical results it is evident that the photoelastic method is reliable for problems in which there is no corresponding theoretical analysis with which to check the laboratory findings.

Besides its use in determining stress concentration factors the photoelastic analysis has a very definite advantage over some other methods due to the fact that it shows the complete stress distribution in the model and gives a graphic representation of the entire distribution at once. On account of this characteristic it can be used to locate regions of both high and low stress with equal ease.

Usually, regions of high stress are emphasized but, in many cases the regions of low stress can be almost as important, since by eliminating material which is not stressed to its safe limit a general reduction in weight can be accomplished. In this respect, cast construction lends itself admirably to conditions of most economical design especially where one is dealing with parts in motion. For static loadings this may not be of such great importance as in those cases involving inertia forces. However, for the latter conditions its consideration should be given top priority due to the fact that by reducing the weight of one moving part the size and weight of supporting parts, in many instances, can also be reduced.

Photoelasticity is by no means a "cure-all" and one of the most important considerations is to know when to apply it and when to leave it alone. It has, however, the advantage that it can solve certain problems which defy solution by any other method and for these cases it is extremely valuable.

Strain Gage Analysis

For many years the practice of measuring strain in models or full sized structures has been carried on with great success and has produced a tremendous amount of useful and valuable data. However, until quite recently, the method has not been well suited for finding stress concentration factors, although its application for finding the general nature of stress distributions has been of untold help to the designer.

The strain gage method embraces the use of a variety of types of mechanical, optical, and electrical strain gages or extensometers and has been limited only by the characteristics of these instruments in relation to the requirements imposed upon them under all possible conditions of operation. Originally, mechanical strain gages were used, and although these can and do produce useful information, nevertheless, they suffer from various limitations, particularly in regard to the possibility of making measurements un-

der dynamic conditions caused by vibration or other rapidly applied loading.

Probably the earliest applications of strain gages are to be found in the studies of stresses in bridges and of tension in tie-rods. As better instruments were developed, other applications of the method became possible. With optical instruments using "light levers" (a beam of light) which have no inertia it was finally possible to make observations under certain conditions of dynamic strain, and to produce exceedingly high magnification. Within the last twenty-five years certain electrical gages have been devised which, in general, have superseded most of the other methods of strain measurement. The introduction of magnetic and carbon strip gages paved the way for a more recent development which has made remarkable progress, and in fact revolutionized the whole field of experimental stress analysis.

Just prior to the war the bonded metalletric strain gage (SR-4 wire resistance gage) came into being. The development of this instrument together with auxiliary equipment has been extremely rapid and its applications, especially in the aircraft industry, have been amazing. With SR-4 gages and associated equipment it is possible to measure and follow tremendously rapid fluctuations (due to vibratory or impact loads) as well as gradually changing, and static stress conditions.

The instrumentation which has developed simultaneously with the wire resistance strain gage has made the analysis relatively easy from the point of view of the interpretation of the data. A great many strain gages read in other than strain units and these in turn must be converted into terms of strain and stress. With the SR-4 gages the actual strain indication is made in terms of changes in electrical resistance, but the apparatus which has been developed for use with them makes all the computations necessary to convert these indications into terms of strain in inches per inch and in some cases even records results on a chart or piece of paper. Commercial instruments can now be procured which will record observations from a single gage (see Fig. 4) with direct visual observation of the computed result or more complicated apparatus which will scan, compute, and record the observations from forty-eight (48) gages every minute and a half.

Interesting applications of these wire gages are to be found in the measurement of stresses in the crankshafts of internal combustion engines during operation and also on aircraft in flight. In the case of tests on flying airplanes it is possible to measure strains on the plane in flight and to record the data on the ground by radio transmission. This procedure not only enables more engineers to watch what is going on, but, in addition, in the event of a crash and subsequent destruction during the test flight, the information is preserved.

Although no attempt will be made in this discussion to go into the details of the different types of strain gages, the wire resistance gage is of such importance that it warrants a brief description. The gages usually consist of a grid of very fine wire cemented to a thin piece of paper (as shown diagrammatically in Fig. 4) and covered by a small piece of felt for protection. The paper is carefully cemented to the surface on which the strains are to be measured and any changes in dimension are transmitted through

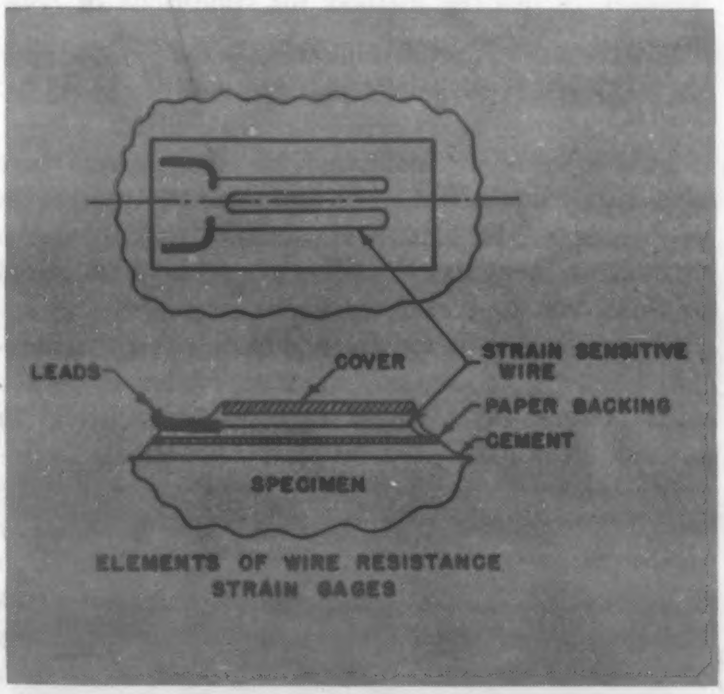


Fig. 4—A schematic diagram of the metalletric wire strain gage.

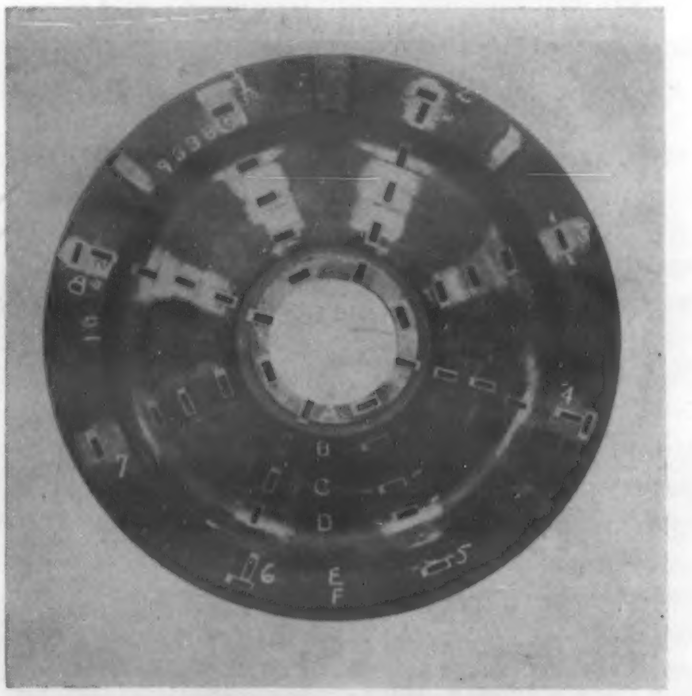


Fig. 5—Wire strain gages mounted on a railway car wheel prior to cutting up the wheel for a residual stress analysis.

it to the wire grid whose electrical resistance changes with the strain. As the wires of the grid are only about 0.001-in. in dia., thicker wires are provided for connecting the grid to leads from the recording apparatus.

All the various methods of strain gage measurement are of course applicable to the study of stresses in metal forms but the wire gages have the peculiar advantage that they can be used for measuring residual stresses by relaxation following the cutting out of the small piece of material to which the gage has been fastened. In future developments this should be of tremendous assistance to all foundrymen and designers of cast structures as well as other types of metal forms. An actual example of residual stress measurement is illustrated in Fig. 5, which shows a railroad car wheel with some 94 gages mounted on it. By means of cutting up the wheel and measuring the released strains, information leading to a change in heat treatment and better characteristics was obtained.

Stress Coat Analysis

Since many castings as well as pieces fashioned by other means are of peculiar geometrical form, one of the difficulties in using strain gage analysis is to determine where and in what directions the gages should be located. Sometimes gage location is quite obvious if we are merely interested in peak stress values. However, if a general survey of the stress distribution in the structure is desired, then the direct application of strain gages will frequently result in a long and time-consuming project unless some means is found to guide the placing of gages most advantageously.

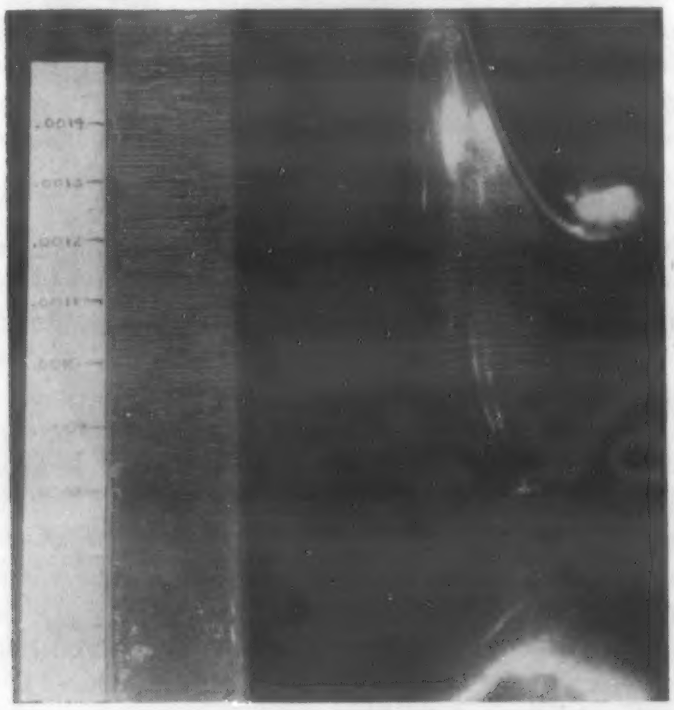


Fig. 6—An example of a stresscoat crack pattern.

Within the last ten years a very simple process has been developed for analyzing stress distributions on the surfaces of odd shaped bodies. The method is particularly useful as a preliminary to a strain gage analysis, and, under favorable conditions, will itself determine stress magnitudes to within about 15% of the correct values. In many cases that is quite sufficient for engineering purposes, but, if greater precision is desired, it can be followed by a strain gage study of the critical locations.

In brief, the method consists of spray-painting the surface of the part, for which the stress distribution is to be determined, with a coating of brittle lacquer. The lacquer is allowed to harden overnight, and the load is then applied. The strain set up by loading will cause cracking of the lacquer at a stress well below the elastic limit of the material and by means of the crack pattern thus formed it is possible to determine the stress distribution not only in the regions of highest stress but also in other regions as well. Since the cracks always occur in the direction perpendicular to the algebraically larger principal strain, this provides a direct method for establishing the directions of the stresses in the structure.

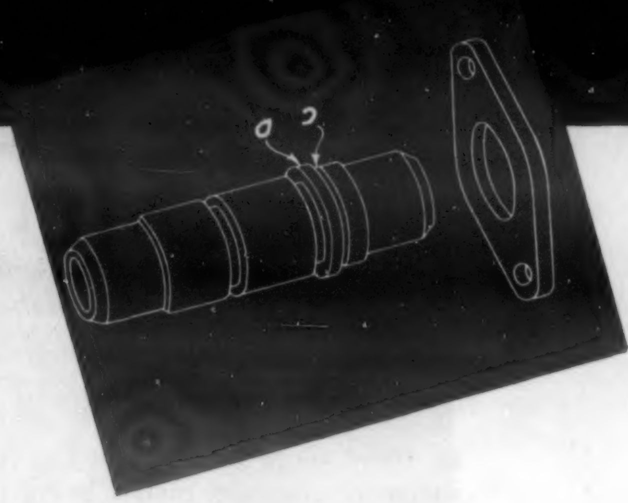
The method is not limited in respect to the kind of materials to which it can be applied and it works satisfactorily on steel, brass, copper, or cast iron. Fig. 6 shows a typical application of stress measurement on a hook (of which only a part is visible).

Since the lacquer ruptures due to a tensile strain, the procedure is only directly applicable to those cases involving tension. However, through an inversion of the stress condition it is possible, by means of relaxation, to use the method for conditions of compression.

Conclusion

In conclusion it should be noted that, as yet, there is no single method of stress analysis which will solve all problems. It is always necessary to choose the method or methods which appear to be best suited to the given case at hand. Sometimes no one approach will lead to satisfactory results and the combined results of several different modes of attack must be used to reach a successful conclusion. In general, all but the very simplest cases should be investigated by more than one method and when the final results of the stress analysis are obtained they should be carefully considered as a guide in relation to fabrication problems and the designer's previous experience, for which there is no substitute. Stress analysis when applied with intelligence yields much useful and fundamental information, and its use as an aid in engineering design of metal products will continue to increase in the future.

The housing of this flanged shaft and the flange are joined by brazing. A ring of silver solder is placed in C (in the drawing) and then the flange is pressed into position against shoulder D. The steel part is stronger and lighter than the casting it replaced.



JOINING

Induction Brazing

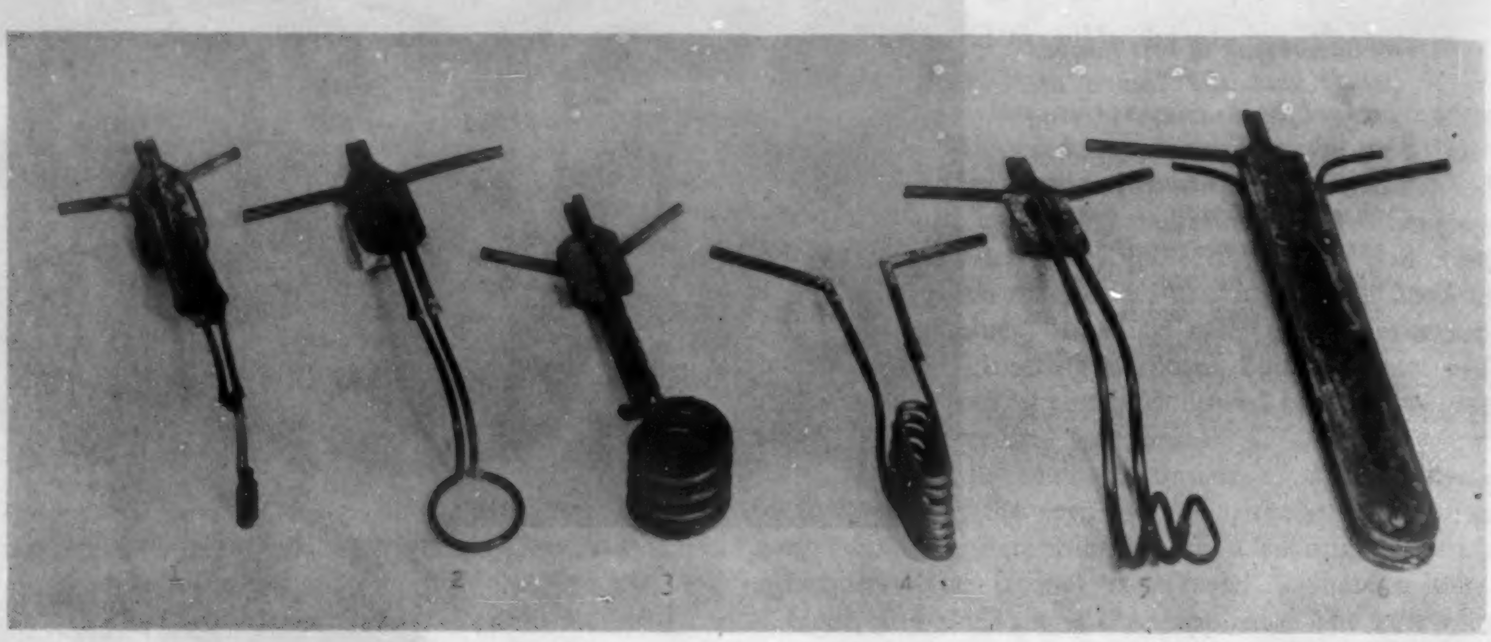
by REX BAUBIE, *Chief, Induction Heating Div., Central Boiler & Mfg. Co., Detroit*

INDUCTION BRAZING, using practically the full range of solders and brazing alloys, fused by electrically inducted heat, promises to take an important place in metal parts fabrication for its unequalled advantages in speed, simplicity of operation, and precise control of variables. This joining method uses brazing materials varying from soft lead solder with a melting point of approximately 400 F to pure copper with a melting point of 1980 F. Probably no fabrication process developed in the past 10 years offers greater advantages to the designer in improvement of the finished product, and reduction of manufacturing cost by lowering the number of rejects and development of largely automatic production processes.

The value of brazing is well recognized, so a brazing process which has the flexible control and other assets of induction heating is of importance.

The newest development in induction brazing is use of interchangeable coils, or inductors, that can be changed as readily as drills or reamers for different jobs, and jigs and fixtures, likewise designed for individual jobs and readily interchangeable. Use of interchangeable coils and jigs makes possible job shop operation, and opens the process to a wider group of manufacturers whose volume of work may not justify installation of induction heating equipment, or placing skilled technicians on the payroll to handle it.

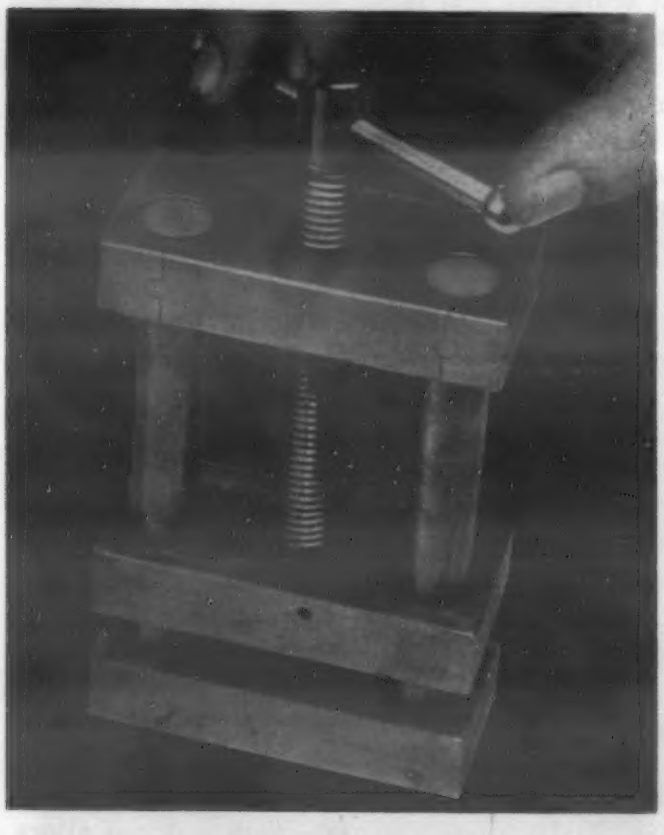
Brazing with silver and other low-melting-point alloys is not new. The most familiar forms are an alloy which is a brass composition containing varying amounts of silver, in wide use by welding shops, and silver solder, long used by craftsmen in fine silver and later in airplane manufacture to join fittings. Today there are more than a dozen alloys, with composition varying according to use. All, however, have one characteristic in common, and this is important in joining metal parts without distortion—



These inductors can be changed readily for different jobs. The inductor at right is used to harden simultaneously the threaded portion of 10 bolts, leaving the heads soft.

all these alloys have melting points below those of the more common metals being joined, which have melting points ranging from approximately 1100 to 2600 F.

One of the more recent developments is an aluminum base solder. Solders of this type have a flow point of 550 F and have an affinity for almost any metal. Experiments have been conducted with this solder in joining aluminum to copper and to cast iron, to soldering magnesium alloys and to joining other metals to these and also in soldering many of the grades of white metal or die cast metal.



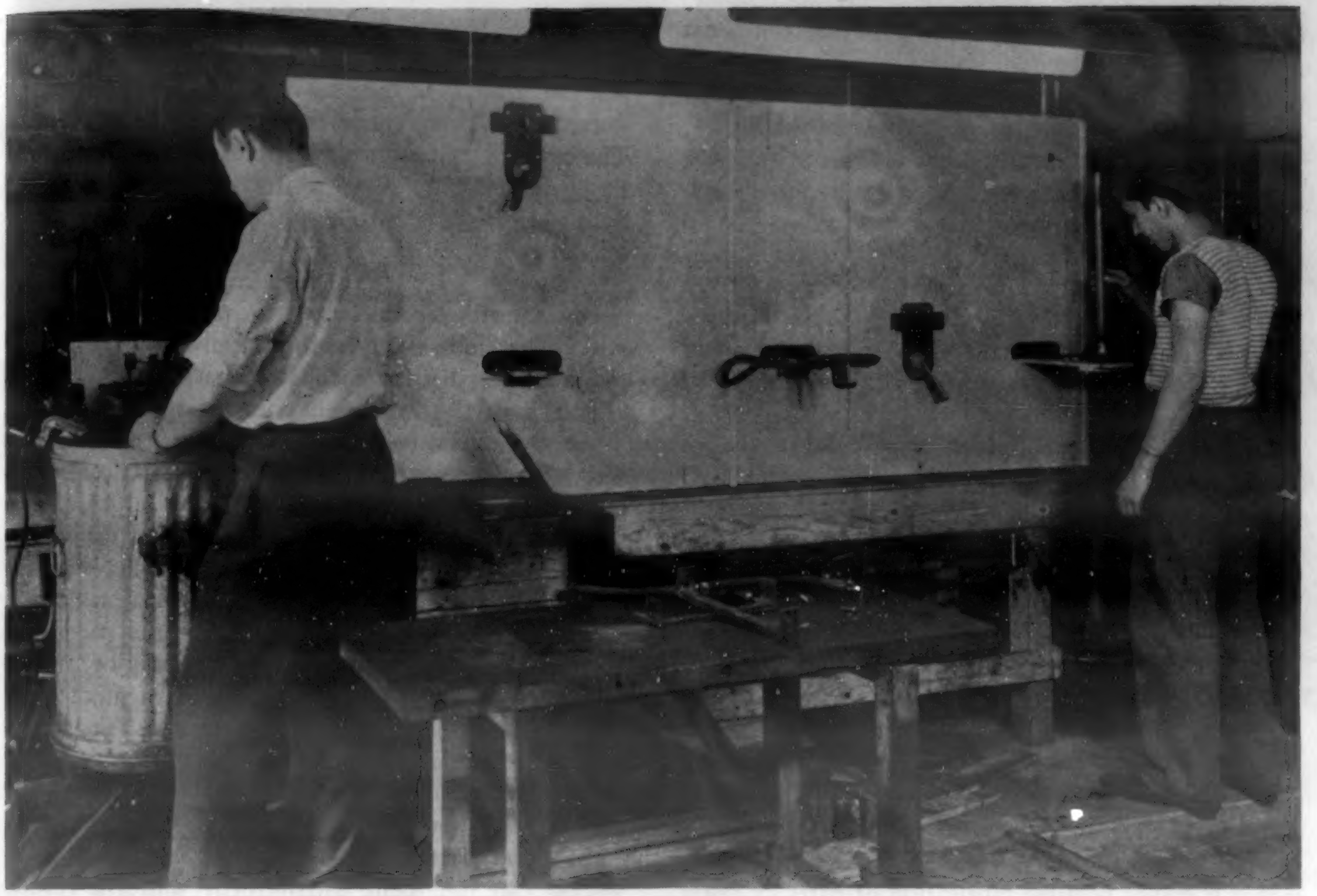
In this vise, a ring of silver solder is placed at the joint of pins and top plate and heat fuses the brazing alloys between the ends of the rods and the top and cross members.

The process itself is not over-complicated. The parts to be joined are placed in position, a predetermined amount of brazing alloy is placed at the joint after application of flux, and the alloy is fused by application of induction heat. Precision manufacture is possible through another characteristic common to all of these alloys—all are free flowing in correct temperature ranges, and produce a strong joint with a clearance between parts of as small as 0.001 in.

There are two basic rules to follow in induction brazing. The first concerns cleanliness. All grease must be completely removed and a clean, bright metal surface obtained before the flux is applied. Second, the brazing alloy chosen must have a lower melting point than either of the pieces to be brazed. This latter point may seem obvious, but there have been many cases in which attempts have been made to copper braze steel parts to aluminum parts.

Control of Variables an Advantage

Control of variables is one of the most important advantages gained by automatic over manual operation; mass production has pretty well exploded the myth of "hand-made" superiority. Variables in brazing are generally heat, time and amount of brazing alloy used. It is obvious that none of these variables can be controlled accurately by an operator using a torch and a piece of brazing alloy, but the controls are far more precise than will be realized outside the field.



In this unit, two high frequency generators deliver a total of 42,000 watts. Operations in four positions at one time are possible. One switch controls the combined generators.

Heat control involves temperature, length of time heat is applied and depth of penetration. Induction heating meets all these requirements, with accurate control and precise timing from 1/60-sec. to 5 min. or more. Depth of penetration can be checked by examination of a cross section, and once established will be constant. The amount of brazing alloy is controlled by using pre-cut pieces, usually from wire or flat stock.

One reason for the success of induction brazing is the ability to provide a large amount of heat and concentrate it just where it is required and to do this rapidly and uniformly. An example of the value of these characteristics is to be found in the case where a 12-in. dia. and 0.015-in. thick diaphragm is brazed to a 12¼-in. dia. ring, ½-in. thick and having a 11⅝-in. bone.

After other methods had failed, induction heating was tried. The part was placed in a slowly revolving tray having running water to a depth of ⅜ in. and the heating coil was then positioned adjacent to the part. By this means, only the top surface was heated. The heat flowed by convection and melted the silver wire which then flowed completely through the joint. Only a small fillet was left and this was removed at the same time as the lip which was provided to retain the silver solder ring.

When brazing is combined with hardening, quench is likewise automatic, with precise regulation of temperature and amount, using hot or cold water, oil or whatever quench liquid may be indicated. By predetermined control of heat and quench, it is also possible to combine with the brazing operation either hardening or annealing the piece in production. One application of this would be joining eccentrics to automotive cam or distributor shafts, and at the same time hardening the cam faces and bearing surfaces.

Wide Range of Products

The wide range of products that can be made by induction brazing includes small crankshafts, attaching shanks to drills and reamers; fastening lugs to hose clamps, formerly a difficult operation, fastening carbide tips to cutting tools, and making hydraulic, pneumatic and refrigerator fittings. While it does not involve brazing, another operation ideally adapted to induction heating is shrinking ring gears on flywheels, a process that has been developed to be entirely

automatic and operated by unskilled workmen. First the ring gear is heated to approximately 400 F and set in position on the flywheel, then the same induction coil heats the teeth to 1500 F for hardening.

For manufacture by induction brazing, a light press fit usually will meet specifications without holding tolerances closer than a few thousandths of an inch. Silver base alloys, with joint clearances of only a few thousandths of an inch, flow in every direction throughout the joint area by capillary action. Brazing alloy outside the joint itself, as in other methods of joining metal, does not add materially to strength of the joint unless fatigue failure is a problem. Under such conditions, a fillet is desirable. Low temperature alloys, with a melting point of approximately 1200 F, will form the strongest joint with a clearance of 0.002 to 0.003 in. while brasses, bronzes and pure copper require clearance of approximately 0.001 in.

In some types of joints it is considered advisable to groove one member so that the brazing alloy can be placed inside the joint before it is heated. While this insures an even distribution on each side of the groove, it is not usually essential in view of the alloy's property of flowing through the joint area. On many pieces it is only necessary to place a ring or piece of alloy at the outside juncture of the joint.

One of the chief advantages of induction brazing is that it makes possible fabrication of parts by faster methods. An example is the flanged shaft housing illustrated in accompanying photographs and drawings. The piece formerly was cast iron, which meant both inside and outside machining, with uniformity questionable because of possible blowholes and other imperfections common to casting.

By the new method, the housing itself is turned out automatically on a screw machine, and the flange stamped from flat stock. No further machining is needed after the pieces are joined, as there is no distortion.

Assembly of a vise, which also is illustrated, is likewise simplified and improved. Brazing makes a strong, rigid joint without danger of cracking the metal, and eliminates two operations involved in drilling holes for, and inserting holding pins.

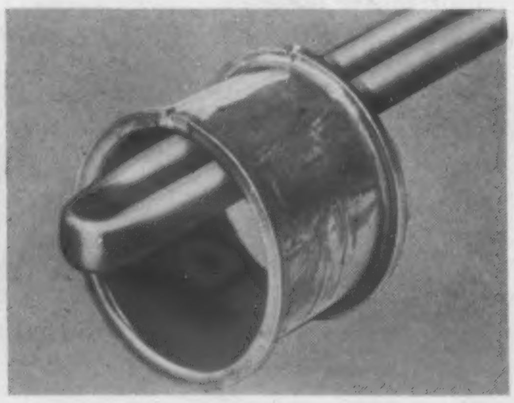
Coil design probably is the most important factor in both induction heating and induction brazing. Correct coil design involves determining where the heat shall be concentrated and how it may be conducted to adjacent members, affecting the operation. The coil can be designed for fixed operation, in which the part does not move while heated, or it can be designed for the part to be turned during the heating operation.

Design of jigs and fixtures for manual or automatic operation will depend largely on the size of the job. For smaller jobs, the type that often come into a job shop, simple jigs for manual operation may be advisable both from the standpoint of speed and cost. With a comparatively small run using manual fixtures, the job might be finished by the time automatic equipment could be built.

Induction heating is still too new to set up equipment in advance with a slide rule and tables. Experienced operators can estimate variables with reasonable accuracy knowing the composition of the metals to be joined and the size of the piece, but only by careful testing can the job be set up right. If a piece is to be hardened, Brinell or Rockwell tests show the results; the same for annealing. A cross section will show the depth of penetration.

If the equipment is set up properly with the correct coils, etc., in such a way that the average worker can use them, satisfactorily uniform results can be obtained. It is of utmost importance, however, that only skilled technicians design the coils and fixtures, as both induction heating and induction brazing call for constant, controlled operation within close limits of heat, time, penetration and quench.

Design of coils requires knowledge of the type of equipment used to produce high frequency electric energy. There are three general types, the electric generator, limited in frequency range to approximately 10,000 cycles per sec.; the resonant spark gap, which produces frequencies between approximately 80,000 and 200,000 cycles per sec.; and the vacuum tube oscillator, with frequency ranges from 200,000 cycles per sec. to millions of cycles per sec. Our shop uses the latter type chiefly because of greater range and output capacity. Two oscillators together have a combined capacity of 42,000 watts.



The pencil (left) shows where bearings, rolled from flat stock, are joined by brazing inductively using a hairpin-type inductor (right). Bearing alloy is bonded to the inner surface.

Low cost tooling materials received considerable attention during the war for forming aircraft parts. Here is one which promises longer service life.

This intricate Plaster of Paris pattern has been protected and made durable through impregnation.

Resin Impregnated Plaster—

A New Low-Cost Tooling Material

by JOHN DELMONTE, *Consulting Engineer, Furane Plastics and Chemicals Co.*

DEVELOPMENT OF SUPERIOR physical properties in gypsum products, and the attainment of necessary temperature and chemical resistance have made available an new low-cost base suitable for small and large tooling problems. This has been made possible by the impregnation of completed plaster structures with newly developed, low viscosity furane resins (Plaspreg). Plaster of Paris patterns and temporary tooling are well known to the metal trades, though generally as intermediates for more permanent tooling. Plaspreg gives plaster a more permanent status, permitting its use under production conditions.

There is probably no simpler material to cast and fabricate than plaster of Paris. Room temperature setting, low in cost, and dimensionally stable, it has few equals. There have been many attempts to strengthen these forms, as through the selection of certain long fibered fillers or adaptation of more costly, more dense plasters, all of which have met with some degree of success insofar as physical properties were concerned, though not in temperature and chemical resistance. All of these properties are, however, enhanced by the materials and processes described in this article. Let us confine our thinking to typical examples of what can be accomplished and the problems presented to the metalworking industries.

In the first place, the art of casting plaster and setting large or small shapes is not changed. In other words, no chemicals are mixed with the plaster which would affect its setting characteristics and ease of handling. The resin impregnant is brushed upon the finished, dried plaster form and unlike shellac or other coating agents which seal the surface only, penetrates into the body of the plaster. True penetration is obtained and can be readily verified by breaking into the plaster form and observing the pene-

The glass cloth part bonded with polyester resin was shaped with the Plaspreg laminating die shown.

tration of the dark-colored furane resin against the white background of plaster. Brushing on the resin will suffice, and this fact is important when considering its use for large stretch press dies measuring as much as 8 or 10 ft. However, smaller parts can be immersed in the resin impregnant. After baking at 140 to 150 F, the new structural material emerges.

One of the first things observed is the darker, bone-like consistency of the material and its ability to take high polish with buffing compounds. This ability is important in connection with stretch press dies for metals because the sheet metal stock will flow more readily upon such a smooth surface. In the event that only a surface penetration of ¼ or ½ in. is desired, partial impregnation followed by partial cure and then a second impregnation to develop a high resin concentration in the outermost skin proves to be most practical. Impregnation of several inches is possible, however, and can be accomplished at atmospheric pressure.

In the preparation of plaster mock-ups for contoured metal parts to be used as check gages, the scratch coating is poured first and then perhaps sealed with shellac. This is followed by the finish coat of plaster which is developed into a precision finish. Subsequent application of resin impregnant is limited to the finished plaster coating, thus developing the necessary properties in the skin or finished plaster where they will do the most good. As compared to earlier prototypes of complete liquid plastics poured and cured, Plaspreg models and mock-ups are much more stable in dimensions, making it a much more desirable method. After-shrinkage is negligible in Plaspreg forms. Drill jigs for metal parts can be considered in Plaspreg because of improved chip resistance and ability to withstand general abuse. Bushings can be spotted readily before the plaster is poured.

While the 300 to 400% improvement in physical properties of Plaspreg over straight plaster is quite remarkable, care must be exercised in its application to fabricating metal parts. It is not a rubber-like material, and its high modulus and relatively low tensile strength mean that relatively little yield is apparent. For example, in hydropress work for shaping sheet metals, a smooth perfectly flat base is essential if the material is to give its best performance. The tools should be designed for compressive loading wherever feasible. Of course, when reinforced with cloth or long fibers, working tolerances are greatly extended insofar as adaptability to metal fabricating problems is concerned.

In the foundry Plaspreg patterns, core boxes, match plates, etc., are finding increasing use due to the much higher operating temperature limits of Plaspreg over untreated plaster. Keller duplicating patterns have found this new material highly interesting and capable of saving appreciable tooling costs. The movement of the stylus over the surface of Plaspreg not only means it contacts a substantially hard area, but also a surface which has reproduced design details with fidelity.

Throughout all the work which has been accomplished in the impregnation of plaster of Paris, it has become apparent that best results are obtained through infusion with low viscosity resins into dry plaster of Paris bodies. There are a number of variables which will influence the rate and ease of impregnation. These are: 1. Inherent resin viscosity in the absence of solvent; 2. Relative porosity of the plaster structure—determined largely by the initial solids/water ratio; 3. Temperature of the plaster of Paris body; and, 4. Presence of impurities upon the surface. Inasmuch as the correct development of the physical properties of Plaspreg depends upon these variables, they will be discussed briefly one by one.

1. *Resin Viscosity*—The resin viscosity has a definite influence upon the rate of penetration into the plaster. The higher the viscosity, the higher is the molecular weight and the slower the rate of penetration. Mobility of the resin and its ability to wet surfaces are functions of resin viscosity, and due to the capillary nature of the diffusion process into plaster bodies, resin viscosity is most important.

Thinning the resin with low viscosity solvents does not produce increased rates of penetration of anything except the solvent, primarily because the plaster of Paris body will act as a filtering medium and separate the higher molecular weight components from their carrier. Other variable factors such as method of application of the resin impregnant will influence the penetration of the resin. Brushing on the resin and keeping it in motion will aid penetration.

2. *Porosity of Plaster*—Porosity of the plaster has a definite bearing on the amount of resin which can be absorbed. It is seldom possible to produce a workable mix of plaster and water with less than 60 lb. of water per 100 lb. of plaster. Of the water used, how-

ever, only 17.5 lb. are required to set the plaster chemically and the balance of 42.5 lb. represents free water. This water is evaporated or forced out by oven drying, leaving voids to be filled by the resin impregnant.

One accompanying graph shows the relationship between the water and plaster ratio and the maximum theoretical pick-up (calculated on the basis of a 1.18 specific gravity resin). Resin pick-up is based upon the total removal of free water after the cast has been made. In addition, the decrease in compressive strength of the plaster is illustrated—indicating that when larger amounts of water are employed, the percentage of voids is greater and the effect upon the strength more pronounced. The values for compressive strength of the non-resin treated plaster are obtained upon dry plaster, which is appreciably stronger than wet plaster. At the same time, the compressive strength of resinified Plaspreg is also illustrated. The reinforcing effect of the furane resin impregnant is quite apparent, as even low density, light weight plasters are considerably improved. The same improvement is also noted if, during the process of drying or during use, some of the water of crystallization is removed. Resin impregnation overcomes weakness or loss of strength in plaster.

Porosity can also be ascertained by the water absorbed and in some processes, such as pottery manufacture, this is an asset. Aside from this application, low water absorption is desirable. In Plaspreg where voids are substantially filled with furane resin, water absorption is very low—less than 2% ASTM water absorption in 24 hr. when properly prepared. Herein lies the utility of Plaspreg tools and articles from a weathering standpoint—they are substantially more satisfactory than untreated plasters. Within a few minutes immersion, most plasters of the 100 plaster/60 water composition will have a water absorption of 25%. Parts will deteriorate rapidly, while non-porous Plaspreg is infinitely more satisfactory.

3. *Temperature of Plaster*—While not of major consequence the temperature of the plaster at time of impregnation will influence the rate of penetration of the resin. By raising the temperature of the plaster, it is possible at the time of resin application to obtain quicker penetration. From a practical point of view, as forms are removed from the drying oven they can be immediately treated with the resin impregnant without waiting for them to cool.

4. *Impurities on the Surface*—There are several types of surface impurities which can influence the rate of penetration of the resin into the plaster. Rate of penetration becomes of practical importance when, for example, treating large surfaces, and uniform appearance is necessary. One of the more common surface imperfections may arise from too liberal a use of parting agent in preparing plaster of Paris molds and patterns. Stearic acid is largely used for this purpose, as are various soaps. These materials, if present, would restrict penetration of resin into the surface. However, if removed by light sanding or finishing operations upon the plaster surface, uniform pick-up of resin is assured.

Another type of surface imperfection finds origin in the mixing of the plaster. This imperfection is known to the plaster trade as a "hard spot." It occurs, generally, on large smooth surfaces, particularly near sharp corners or edges where rapid drying occurs. The hard spots are due simply to portions of plaster not too thoroughly mixed with the balance of the batch. If this is the case, such that a higher solids to water ratio is present, the plaster will tend to be harder, and porosity a little less. Once again, however, light sanding over this region will make the pick-up of resin more uniform.

Amount of Resin Required

While best physical properties are obtained upon fully impregnated forms, it is also feasible to consider surface penetrations of ¼- to ½-in. without necessarily going through several inches of plaster. For many contour blocks and tools this procedure has been followed for reasons of economy and a good hard surface obtained without full treatment of the plaster. The amount applied can be controlled to some extent by the number of times the surface is gone over with a brush that has been saturated with liquid furane resin. Absorption of resin into the surface can be likened to the absorption of ink into a piece of blotting paper. Penetration takes place instantaneously upon the initial application, though at a slower rate after 10 or 15 min.

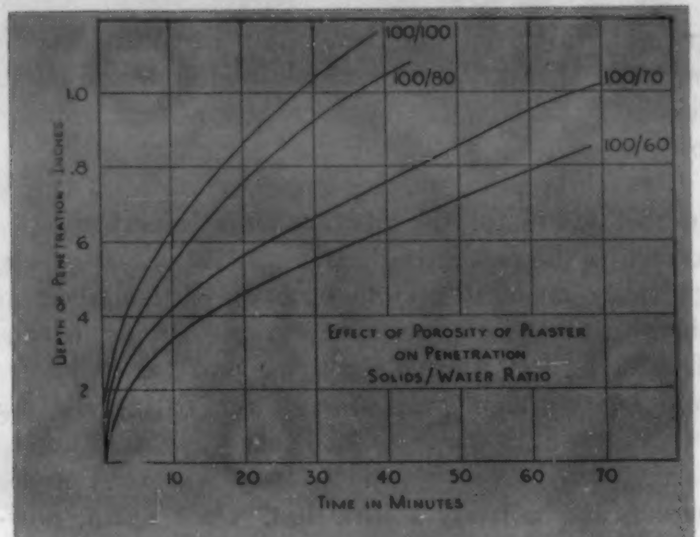
While vacuum and pressure vessels have been employed to obtain even faster and more thorough penetration, the entire procedure is conducted at atmospheric pressure and temperature. When thin, low viscosity resins are employed, the amount of build-up on the surface is negligible. However, when high viscosity impregnating resins are employed, there is some build-up on the surface which must be wiped off before the part is cured. For greatest accuracy of dimensions this is quite important.

To make quick estimates of the amount of resin required to completely impregnate a plaster of Paris body, the article is weighed and approximately 40% of its weight is prepared in impregnating resin if complete induration is required. The actual amount required depends, however, upon how thorough a penetration is desired, how well the plaster has been dried, and the other variable factors described on the preceding pages.

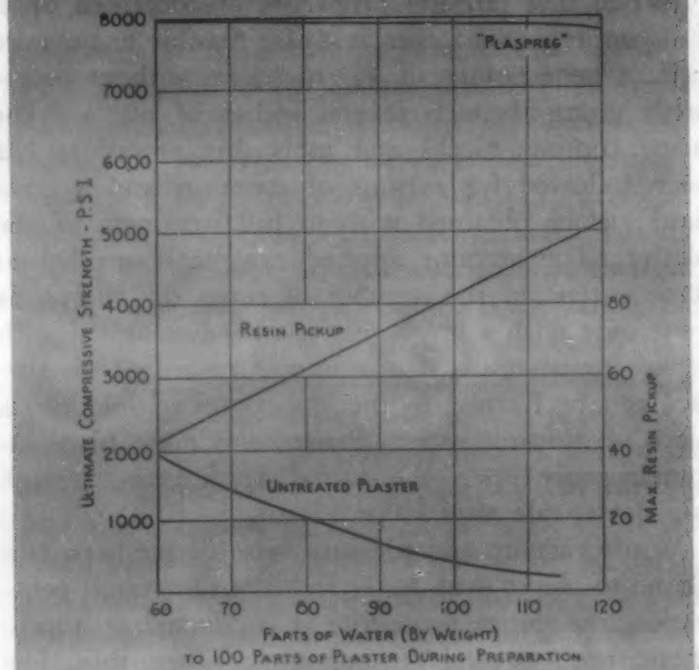
Curing Impregnated Plaster

After the plaster has been properly impregnated, it is cured to develop optimum physical properties, which are consistently a 300 to 400% improvement

over the straight plaster of Paris structure. The curing procedure does not invite any special complications, simply requiring placing the form in an oven and slowly raising the temperature to about 145 to 150 F. The rate at which temperature is raised or the rate at which it is lowered must be conducted, of course, with concern for thermal expansion and shrinkage characteristics in order to avoid the development of internal stresses at any position such as may mark the meeting of a thick or thin section of material.



While a very slight initial shrinkage can be observed, of the order of 0.050%, the after-shrinkage of Plaspreg is negligible and dimensions are held with utmost accuracy. At the same time these tests were made, the thermal expansion coefficient was determined at 0.000022. This value approximates the expansion coefficients of aluminum alloys. This property has been utilized to advantage in providing for localized reinforcement of Plaspreg at positions of high stress concentration. The insertion of aluminum alloy strips or corners, folded from sheet metal, gives the end product greater toughness where it is most needed.

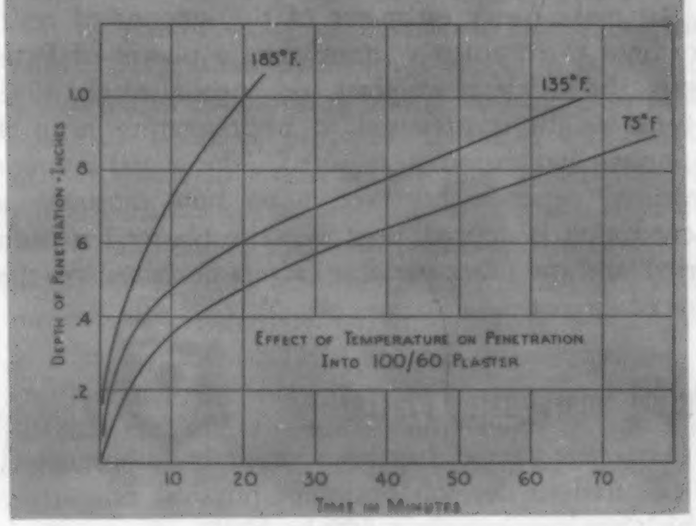


Temperature Stability

One of the most important gains registered in Plaspreg over unimpregnated plaster is improvement in temperature stability. This has already been indicated in part by pointing out that the material has a negligible after-shrinkage. The study, however, goes deeper than that, and in two respects Plaspreg is far superior to ordinary plaster:

1. Maximum continuous operating temperature which it will withstand without suffering any permanent change in physical properties is in the neighborhood of 180 F. This value is appreciably more than straight plaster, the temperature limit of which is about 120 F because above this it loses water of crystallization and strength. Likewise, the liquid casting resins have temperature limits of about 140 F or thereabouts because at higher degrees they shrink too excessively.

2. The maximum temperature at which Plaspreg can operate continuously and still be stronger than the initial plaster is about 230 F. Above 180 F, the strength may fall off slowly to a certain level and then stop—though it will be stronger than the original plaster of Paris. This has been quite important to foundry work where plaster forms and core boxes have not been considered because of the rapidity with which they lose strength when raised in temperature.



Permanency of the physical properties of Plaspreg is indicated by the retention of its strength over a long period of time. Impregnated bodies prepared a few years ago test as strong as when they were first cured. To accelerate the aging of Plaspreg, a constant temperature oven at 185 to 190 F is used and com-

pressive strength observed after various intervals of time. The loss in strength of Plaspreg is due to loss of strength in the plaster occurring on removal of water of crystallization at high temperature. Retention of strength after exposure to high temperatures is indicative of not only the permanency of the materials, but also of operating temperature limits. As is the experience of most thermosetting plastics, short exposures to high temperatures far in excess of continuous operating temperature limit will not be damaging.

Limiting factors in the temperature resistance of Plaspreg are, first, the loss of water of crystallization and, second, the temperature limits of the furane resin polymer—which lie about 250 to 300 F. Further improvements in temperature stability can be realized by substituting an inert filler such as powdered silica for part of the plaster of Paris. This can be accomplished without weakening the total cured structure.

Chemical Resistance

The chemical resistance of Plaspreg is much more satisfactory than is that of untreated plaster. Not only is water absorption greatly reduced because of the presence of furane resins to fill the voids, but furane resin solids (100%) show an ASTM water absorption of less than 0.05% in 24 hr. For maximum weather protection, Plaspreg toolings are polished or rubbed by hand with a wax suitable for finishing purposes. This will enable parts to be stored in the open, whereas in the past, plaster has fallen apart or was seriously weakened by such exposures.

Strong acids and alkalies affect Plaspreg only slightly, whereas they cause untreated plaster to decompose. As evidence of the good chemical resistance of Plaspreg, various parts have been electroplated after first applying a thin high polymer film followed by stannous chloride and then a silvering solution. Direct deposits upon Plaspreg have also been accomplished.

For general chemical and temperature resistance, the parts shown in an accompanying photograph illustrate the utility of Plaspreg as tooling for low pressure laminating. The service life of plaster parts is increased appreciably due to the much higher strength. In addition, forms are rendered impervious to various polyester resins which must be cured at temperatures as high as 300 F. In the illustration shown, XRS-16631 served as the laminating resin for glass cloth, which was cured under vacuum pressure. A vinyl resin lacquer provides a good release agent for the parts in question.

Property	*Unimpregnated Plaster*	*Plaspreg—No Filler*
Specific Gravity	1.15 (Dry)	1.65
Compressive Strength	1500-1800 psi.	7500-8000 psi.
Flexural Strength	400-500 psi.	2500-3500 psi.
Impact Strength-Charpy un-notched	0.15-0.25	0.8-1.2
Water absorption—% in 24 hr.	35%	2%

Physical Properties of Reinforced Plaspreg

The discussion so far has centered upon furane resin impregnated plaster of Paris. Results are even more noteworthy when various reinforcements are included in the plaster. Long fibers such as hemp or sisal fiber have been known to strengthen plaster patterns and tooling. They likewise add considerably to the strength of Plaspreg. Glass flock, in particular, is effective in forming a strong and tough body which can take much mechanical abuse, and its introduction into plaster before impregnation is an important step. On the other hand, fillers such as diatomaceous earth and walnut flour have a weakening effect on plaster through a strengthening action on Plaspreg.

In conclusion, it appears desirable to sum up some of the advantages and disadvantages of Plaspreg:

1. *Low Cost*—Plaspreg is prepared from a low cost base material, plaster of Paris, which costs about 1 cent per lb. Even when fully impregnated, the cost of Plaspreg is less than that of a thermosetting cast phenolic resin.

2. *Ease of Fabrication*—From the standpoint of ease of fabrication and workability, plaster has few equals. In the Plaspreg process, plaster or Hydrocal tools, forms, or patterns are prepared in their usual manner and set at room temperature. A very stable structure is prepared with simple tools. Upon resinifying and hardening, this form is rendered permanent.

3. *Physical, Chemical and Thermal Properties*—These properties have been vastly improved over the straight plaster—placing fully impregnated Plaspreg in the same class as liquid cast resins—with the important advantage of zero after-shrinkage.

4. *Applications*—No form is too small or section too big to be handled by the Plaspreg process. Resin penetrations up to several inches have been accomplished at room temperature and atmospheric pressure. Wherever plaster is used, resin impregnation can be applied to convert these articles to permanent, stronger materials of construction.

Disadvantages:

1. *Drying*—For best results the plaster forms should be thoroughly dried out. This necessitates an additional step in preparing plaster and lengthens the time lapse before the tool can be used.

2. *Breaking*—While all physical properties are improved some 300 to 400%, Plaspreg forms can still be broken, and one should not expect the treatment to convert plaster into a rubber-like unbreakable material.

1 *The first step in producing precision castings is the preparation of a "master pattern" from the customer's blueprint. The pattern is of brass, steel, Stellite alloy, wood or other material depending on the part's design. The master pattern is a replica of the desired piece, made slightly oversize to allow for shrinkage.*

MELTING AND CASTING

Mass Production of Precision Castings

A Pictorial Visit to Haynes Stellite Co.

ONE OF THE MOST MODERN PLANTS for the mass production of precision castings is that of Haynes Stellite Co., Kokomo, Ind. The "lost wax" process was used experimentally since 1937, but real mass production was not started until after the start of the war. In all a total of 25 million turbo-supercharger buckets were made in this plant, with production reaching a peak of 2,100,000 perfect Type B buckets in one month.

With the end of the war, demand for precision castings underwent a transition so that now production is in progress on such parts as reciprocating slides for cloth cutting machines, fuel parts for aviation carburetors, horseshoe caulks, zipper slides, diesel engine parts, glass mold cut-off rings and many aircraft and aircraft engine and gas turbine parts.

The largest part Haynes has made is the propeller hub for the "Ercoupe," which weighs about 3 lb. With present pressure casting furnaces, 5 lb. is the maximum weight casting that can be handled, and maximum dimension in one direction of 7 to 8 in. At the present time Haynes does not feel that it is practical to produce to tolerances closer than 0.003 in., and prefers to work to ± 0.005 in.

This pictorial presentation serves well to complement the Manual on Precision Castings, which appeared in the March 1946 MATERIALS & METHODS.

—T. C. D.

Precision casting has emerged from the war as the newest mass production process. The methods used by Haynes to achieve amazing output are shown here.

2 *At Haynes, injection dies are prepared of a bismuth tin alloy from the master pattern. These dies are a negative of the master pattern. To make the die, half the pattern is imbedded in plaster and metal poured around it. After the first half of the die is finished, the plaster is removed and the second half of the die is poured. Here is a completed die.*

3 *Wax used in the precision casting, or "lost wax," process is carefully blended from the raw materials and then is molded in blocks. When ready to be used, blocks of wax are removed from the mold and melted as needed to load the guns used for injecting the wax into the dies.*

4 *Necessary cores are placed in the die and wax is injected into the die by means of a "gun," such as shown here, which is emptied by a pneumatic ram.*

5 *The hardened wax pattern is removed from the die and any cores that have been used also are removed. The wax gate is broken off manually. These wax patterns are replicas of the master pattern.*

6 *Operators on the assembly line of the wax department inspect the wax patterns as they move by on the conveyor belt. Patterns are then assembled to gates and risers by "wax welding" and are mounted on wax hubs molded especially for the purpose.*

7 *In this view, the operator is joining blind risers to the wax patterns. Such risers are used to make sure that the metal reaches all points of the mold, and to take care of shrinkage.*

8 *The complete wax assembly is dipped in very fine silica suspended in a suitable medium. The presence of this fine material next to the wax is responsible for the casting's smooth finish, since, when the wax is melted out, this is the surface on the inside of the mold which will be adjacent to the molten metal.*

9 *After dipping, the pouring end of the wax assembly is mounted on a steel base and any areas not covered by dipping are sprayed with silica. Somewhat coarser grains are then "stuccoed" to the dip coating. Shown here is the assembly emerging from a dehumidifying tunnel. The drying process takes 22 min.*

10 *The dried silica-coated wax assembly is scaled in a flask, with wax, to make sure it is liquid tight. The flask is in a wax paper roll that is longer than the flask to hold surplus investment material that later is cut off. Next, as shown here, the flask is filled with a chemically-hardening investment material.*

11 *After the mold has been filled with the investment mix it is placed on a vibrator. Vibration from the table packs the investment material tightly around the wax assembly and eliminates all air from the mold. After about one hour the investment has set and all fines have risen to the top.*

12 *Excess investment material is cut off and the mold ages for several hours, after which the steel plate is knocked off to expose the mouth into which metal will ultimately be poured. Next, molds are placed upside down in a continuous furnace. As the molds progress through the hotter zones of the furnace, the wax is burned out. Molds are heated to from 1300 to 1900 F depending upon the part.*

13 *In the meantime, raw materials for the alloy are accurately weighed, ready for melting in electric furnaces from which pigs are cast for use in small indirect-arc furnaces from which the molds are filled.*

14 *When the metal reaches its correct temperature, the hot, baked mold is inverted and placed directly over the pouring spout of the furnace. After the mold is clamped in place, the furnace is inverted for pouring. Air pressure is used to make the metal sound and dense and to permit casting of thin edges.*

15 *The filled mold is allowed to cool slowly for about 4 hr., after which the entire casting assembly is knocked from the mold. Excess investment material is removed and the cast assembly is carried by conveyors for removal of gates and risers.*

16 *Numerous rough finishing operations include removal of gates and risers and shot blasting. Castings which pass rough inspection are moved to the grinding department where gate areas are smoothed and surface irregularities removed. Finally, the castings are sand blasted to provide a highly satisfactory surface.*

17 *All castings are checked visually and dimensionally. Those which pass are then subjected to Zyglo inspection before the final X-ray inspection. Here a radiographer studies parts radiographs.*

CONTENTS NOTED

A monthly department dedicated as a forum for the interchange of ideas between readers and editors. All readers are urged to take advantage of this space and participate in the discussions presented.

Sodium Hydride Descaling

To the Editor:

In the January issue of MATERIALS & METHODS there is a misstatement which we wish to correct.

We refer to the article on "Cleaning and Finishing" by T. C. Du Mond on page 141, in which it is stated, "Essentially the process consists of dipping parts into molten caustic soda containing metallic sodium."

Technically this is incorrect. The sodium which is added is converted to sodium hydride, and since the importance of the process depends on the presence of sodium hydride the above sentence should properly read "—— containing sodium hydride."

H. L. Alexander
Manager, Metal Descaling
E. I. du Pont de Nemours & Company
Niagara Falls, N. Y.

We appreciate this correction on the part of Mr. Alexander who is Manager of the Metal Descaling Department of the du Pont Company, one of the originators of the sodium hydride descaling process. A complete description of the process as used in one steel plant will appear in the May issue of MATERIALS & METHODS.—*The Editors.*

The "Calutron"

To the Editor:

Please refer to MATERIALS & METHODS, January, 1946, p. 3, where the electromagnetic method of separating uranium isotopes is briefly described in the Production Frontiers department. The second sentence reads: "The Machine, a Westinghouse creation called the 'Calutron,' . . ."

Since this machine is a mass spectrograph, it dates back directly to J. J. Thompson prior to World War I with important contributions since by Aston, Dempster, Nier and others. The word "creation" evidently does not thus refer to its early origins.

Reference to the Smyth Report shows the application of the Calutron to the nuclear bomb project was far from being exclusively a Westinghouse contribution. To begin with, Smyth (11.5) gives the derivation of the name as "a . . . 'calutron' (a name representing a contraction of 'California University cyclotron')." In (11.4) and (11.6), E. O. Lawrence is given credit for early work on this device and was in charge of the University of California group of scientists, a number of whom are mentioned, including E. U. Condon and J. Slepian from Westinghouse. In (11.9) credit for the electromagnetic separation plant itself is apportioned six ways as follows: "The Radiation Laboratory at the University of California was responsible for research and development; the Westinghouse Electric and Manufacturing Company for making the mechanical parts, i.e., sources, receivers, pumps, tanks, etc.; the General Electric Company for the electrical equipment and controls; the Allis-Chalmers Company for the magnets; the Stone and Webster Engineering Company for the construction and assembly; and the Tennessee Eastman Company for operation."

Since the electromagnetic method appears to have been a most important source of fissionable material (for nearly a year it was the only plant in operation), (11.37), and it was in large scale operation during the winter of 1944-45 producing bomb quality material (11.42), there is so abundant credit for all I am sure calling attention to the share of the other associated groups will in no way be considered to detract from the great role Westinghouse played in this and other parts of the project.

Albert Thomas Fellows
Willow, New York

We are sorry that our reference to electromagnetic methods of separating uranium isotopes failed to give proper credit to the University of California for its work in developing this important device. As Mr. Fellows points out, several companies including Westinghouse share the credit for the development and manufacture of the Calutron.
—The Editors.

High-Speed Photography

To the Editor:

I have read with interest the article on high-speed movie cameras that appeared in the February, 1946 issue of MATERIALS & METHODS. In the preparation of any article as comprehensive as this, it is difficult to avoid errors, and when information is taken from existing files, there is little opportunity to determine whether or not it is up to date. I feel that the author did an excellent job of covering a subject on which there is very little published information. However, the reference to the Edgerton high-speed movie equipment manufactured by the General Radio Company contains a number of misstatements that I feel should be corrected.

The upper limit of flashing speed of this equipment is at present between 1500 and 2000 frames per second, while this is well below the maximum speeds obtained by the Eastman and Fastex cameras. The General Radio equipment is capable of photographing much more rapid motion than are the other two cameras by virtue of its

(Continued on page 1025)

CONTENTS NOTED

Continued from page 1023

extremely short effective exposure, which amounts to a few microseconds. The limiting factor is the amount that the image will move on the film during the exposured time, and hence even at 8,000 frames per second on the Fastex 8 mm. camera, the effective exposure is considerably longer than that of the Edgerton equipment. Little, if any, is gained by going to the 8,000-frame speed unless the object to be photographed is moving sufficiently slowly to produce no blur.

The weight of the equipment as stated in your article is entirely in error. The complete equipment consisting of power supply, lamps, and camera weighs less than 250 pounds. Your article details a number of special lighting arrangements that have been used with the Fastex and Eastman cameras, and I suspect that some of these would weigh at least as much as our equipment.

The price of the complete outfit is approximately $3,000.00, and this includes the services of an engineer to set up the equipment and instruct the purchaser in its use.

As you point out, the General Radio high-speed photographic equipment has found its principal use in the research laboratory rather than in industrial trouble shooting. This is undoubtedly because it is capable of arresting considerably faster motion than are the other two cameras, and hence can be applied to research problems that are much more advanced than those encountered in industrial plant maintenance. Often when the Fastex and Eastman cameras are used for these ultra-high-speed applications, a Stroboscope has been used as the light source.

C. E. Worthen

Publicity Manager
General Radio Company
Cambridge 39, Mass.

Thanks to our reader Worthen for his corrections and additional information on the subject of high-speed movie cameras. We are sorry that the inaccuracies appeared, but as suggested, such inaccuracies occasionally occur from reference to older literature.—The Editors.

Composition of Aldecor

To the Editor:

The composition published in your January issue, page 88, (Steels and Irons, review article) is not the analysis of "Aldecor," but that of U. S. Patent No. 2,378,437, awarded to the late Dr. B. D. Saklatwalla.

"Aldecor" is the name of a well established high-strength steel having the following composition:

C	.12 Max.	Si	.30 - .75
Mn	.15 - .40	Cu	.35 - .60
P	.08 - .15	Mo	.16 - .28
S	.05 Max.		

It has a yield point of 50,000 psi. minimum; tensile strength, 70,000 psi. minimum; elongation in 2 in.—22% minimum.

It is manufactured by the Republic and Carnegie-Illinois Steel Corporations and the Lukens Steel Company, and is proving itself to possess excellent forming and welding characteristics, as well as a substantial degree of corrosion-resistance.

William B. Brooks

Metallurgist and Welding Engineer
Alloys Development Company
Pittsburgh, Pa.

We take this opportunity to set the records straight on the correct composition of Aldecor and regret that due to a mixup on our part in studying information released by Alloys Development Company the wrong analysis was published.—The Editors.

Clad Stainless Steel

To the Editor:

My attention has been drawn to your article in the November, 1945 MATERIALS & METHODS, entitled: "Important Cladding Techniques," condensed from *Steel.*

Unfortunately, the article in its condensed version did not mention the most important point of all, and that is how the cladding is successfully made. The process that Mr. Townsend employs at the Jessop Steel Company is known as the Armstrong Process, wherein the stainless steel is electroplated with iron, and this is juxtaposed against low carbon steel backing plates, and after the assembly is electrically edge welded, the whole is rolled down together and thereafter separated, producing two perfectly uniformly clad plates of stainless clad, and that cannot be said about any other process.

Thousands of tons of stainless clad have been produced by my process, not only in the United States, but also in Europe.

P. A. E. Armstrong

Westport, Conn.

We are sorry to learn that the digest referred to omitted one important feature of the original article, mainly the reference to the Armstrong Process. Mr. Townsend's article did not indicate just what process he was primarily concerned with, but it is unfortunate that we gave space to other processes described and completely overlooked this important process.—The Editors.

Plastic Engine Coating

To the Editor:

Your article on the "Brazed Stampings Basis of New Auto Engines" was very interesting and informative.

In one paragraph you refer to a clear hard coat of plastic placed on the inside of a water jacket, and which, after baking becomes so durable that it cannot be removed by caustic solutions.

We are searching for such a material for use in the tub of our new automatic. Would you care to give me information as to the name and source of supply so that we might check further on this material.

Karl Groves

Materials Engineer
Apex Electrical Manufacturing Co.
Cleveland 10, Ohio

The plastic material used in this engine (see MATERIALS & METHODS, *February, 1946, page 439) is made by Ault & Wiborg Corporation, Dana & Thomas Aves., Cincinnati, Ohio. It is our understanding that this company makes several types of impregnating compounds and coatings for applications to metals.—The Editors.*

WE HAD TO INVENT A NEW PROCESS

...to achieve these properties in a powder metal part

The conventional powder metal part is porous. Sometimes that's desirable. *Sometimes it isn't.*

If you're reaching for top tensile and impact strengths, or extra hardness, or the ability to electroplate or machine the finished item—you *don't* want a porous structure.

That's why we're happy to announce that our research has produced *a new and non-porous type of powder metal part*—SINTEEL-G. It's a sintered steel compact in which every interstice is filled with a copper-base alloy—the iron-base skeleton and the copper-base filler being "cemented" into one continuous alloy structure.

But there's more to the material than strength, heat treatability, platability, and machinability. SINTEEL-G pieces can be made more cheaply and in larger sizes. Several simple parts can be self-brazed together (without flux) into more intricate shapes than can be pressed in one piece.

Your cue is to determine which parts of *your* product should be made in SINTEEL-G. Perhaps our invention will prove to be your progress.

Write, phone or wire

AMERICAN ELECTRO METAL CORPORATION

YONKERS 2, NEW YORK

Offices in Chicago, Dayton and Detroit

POWDER METALLURGY SINTEEL FOR MASS PRECISION

JMLCo-AM-D1

MATERIALS & METHODS MANUAL

14

This is another in a series of Manuals on engineering materials and processing methods, published at periodic intervals as special sections in Materials & Methods. Each of them is intended to be a compressed handbook on its particular subject and to be packed with useful reference data on the characteristics of certain materials or metal forms or with essential principles, best procedures and operating data for performing specific metalworking processes.

Engineering Bronzes

by KENNETH ROSE

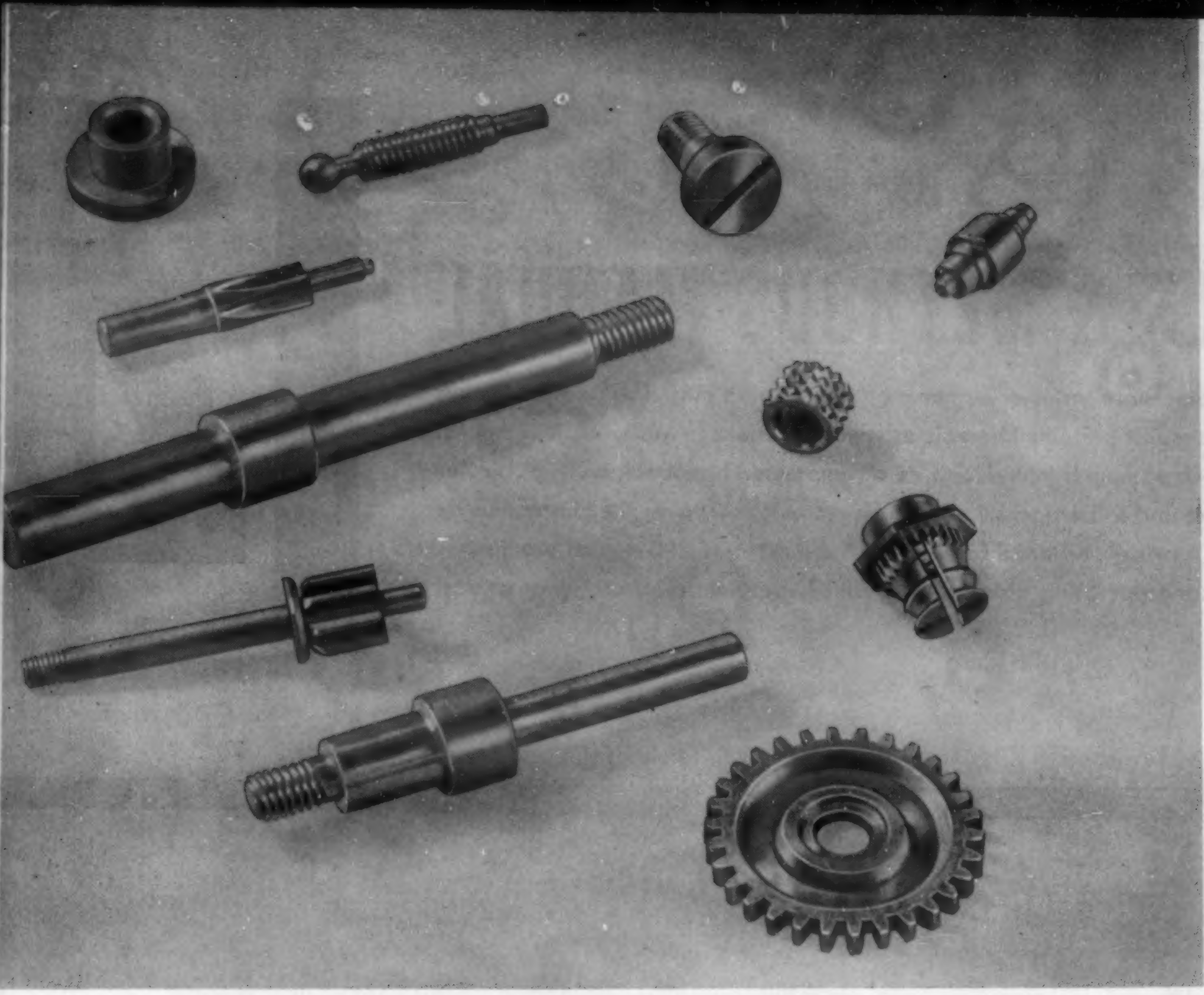
Engineering Editor, MATERIALS & METHODS

"Engineering Bronzes" is a designation applied to those copper-base alloys, developed in recent years, that approach—indeed in some ways exceed—properties of the best steels. Here these distantly related materials are classified for convenience. Among the "engineering bronzes" can be found alloys which offer a wide variety of characteristics that permit a choice for most any type of application. In addition to listing compositions and characteristics of the alloys, this manual presents working information to guide users in forging, heat treating, machining, casting and cold working.

Contents

Materials & Methods, April 1946

(Published Since 1929 as Metals and Alloys)



Free cutting alloys of phosphor bronze contain from 1 to 2% lead. Such alloys are used for machined products such as these precision meter parts. (Courtesy: Riverside Metal Co.)

Introduction

Copper, the first metal to be utilized by man, alloys readily with many metals to provide materials of increased usefulness to industry. Copper hardened with tin in either natural or man-made alloys formed the fundamental material for cultural development antedating the use of iron, and remains today one of the basic types of metallic materials.

With the development of hardenable steels the softer and less versatile brasses and bronzes went into temporary eclipse as engineering materials, although still holding an important place as materials of construction where corrosion resistance, cold formability, bearing properties, and (later) electrical conductivity were paramount. In recent years there have been developed new copper alloys, some of them susceptible to improvement in strength properties by heat treatment, some offering increased corrosion resistance, and some with physicals approaching those of the best steels. These alloys, truly engineering metals, are grouped here as the engineering bronzes.

The term "engineering bronzes" has no standing in metallurgical terminology, but is coined as a convenient expression to designate these alloys, otherwise unrelated. The word "bronze" is itself almost without metallurgical meaning today. While the classical definition of a bronze would be "an alloy of copper and tin," the material offered as "commercial bronze" contains no tin in its nominal composition. Other alloys contain copper and zinc with a small percentage of tin added, and these are properly referred to as "tin brasses," although they might be entitled to the designation of bronzes under the definition. Finally, there is a growing use of the term "beryllium bronze" to indicate those copper-beryllium alloys usually termed beryllium copper. In this case the word "bronze" is used to mean a copper alloy of superior properties, and has nothing to do with tin content.

The lay acceptance of the term bronze as indicating a superior material is quite definite and widespread. Copper alloy manufacturers recognize this thinking in their use of the word in connection with many commercial alloys that could not stand with the copper-and-tin definition. Use of the term "engineering bronzes" to mean those copper alloys, with or without tin, showing engineering properties has therefore a certain sanction from trade custom.

The distinctive properties of copper that make it so valuable in modern technology are high electrical conductivity, high thermal conductivity, fair strength, excellent resistance to atmospheric or sea water corrosion, or to attack by many chemicals, excellent malleability, and receptivity to many kinds of finishes. These properties are present to a considerable extent in the engineering bronzes also. A variation in properties is obtainable by alloying, along with additional variations due to method of fabrication. Additional properties conferred by alloying that are important in influencing the choice of certain of the engineering bronzes for industrial applications are pleasing color, acceptable anti-friction properties, and ease of fabrication, particularly of machining and forging.

General Classifications

A wide variation in properties is available within such a broad category as the engineering bronzes. However, the various alloys show certain broad features that control their selection and specification.

The aluminum bronzes offer excellent resistance to acid corrosion, good casting properties, good strength properties in the heat treated condition, and ease of hot or cold working, according to the composition of the particular alloy being considered. An additional advantage of importance in the aircraft industry is the 10% weight saving possible with the high strength heat-treatable alloys. The golden color of the low-aluminum alloys fits them for many decorative uses. The factors determinative to its selection, then, are the combination of strength, corrosion resistance, and ease of fabrication.

When service at elevated temperature is one of the requirements, and conditions require a copper alloy, aluminum bronze should be considered. Its resistance to scaling and oxidation at elevated temperatures is the highest of the copper alloys.

Aluminum bronze is lower in cost than the stainless steels, and is more easily fabricated. It is not subject to dezincification as are most of the brasses. Its resistance to alkalies is rather poor, however, and it should not be specified where strong caustic must be handled.

While the silicon bronzes are not hardenable by heat treatment, they can, by proper work hardening, attain strengths equal to those of the aluminum bronzes. Corrosion resistance is essentially equal to that of copper. The particular combination of properties deciding in favor of silicon bronze is ease of welding, corrosion resistance, and strength about equivalent to that of mild steel.

Silicon bronzes are not subject to dezincification, and can therefore be used under corrosive conditions for which the brasses would not be satisfactory. Underwater marine use is an instance. Ease of fabrication in general is a characteristic of these alloys, and they can be cast, cold- or hot-worked, and machined without difficulty. Because they can be readily welded by all methods, they should be given first consideration when fabrication of a corrosion-resistant part would include welding.

Phosphor bronzes offer a wide range of service possibilities within their own group, depending upon the alloy. In general, they are utility alloys possessing corrosion resistance approaching that of copper, with higher strength values. They also show good resistance to fatigue, and are extensively used for making corrosion-resistant springs. Low-tin grades provide high electrical conductivity as a special property. High-tin alloys possess greater strength and toughness. Leaded phosphor bronzes are free machining types, especially suitable for parts that are best produced on screw machines or that require unusually good machining qualities. The same alloy possesses anti-friction properties due to its high lead content, and is a preferred material for bearings.

Another material to be given consideration when corrosion-resistance must be combined with high strength and hardness is beryllium bronze. It is rather expensive. Like the engineering steels, it can be fabricated in the unhardened condition and later heat treated to develop the high strength properties required. It possesses high fatigue resistance and is an ideal material for springs. Beryllium bronze maintains its spring characteristics better than any other corrosion-resistant material.

Beryllium bronze includes fairly good electrical conductivity among its desirable properties, and is ideally suitable for springs that must also serve as conductors in electrical apparatus. Electrical fuse clips, contacts, and similar parts make use of this combination of properties. It is practically nonmagnetic, and this combined with its excellent physical properties and corrosion resistance prompted its use for many aircraft parts in wartime, when cost was not an important factor. Engine gears, cowl hinges, parachute clamps, and radio and instrument parts were some of the military applications.

There are parts for which electrical conductivity must be high, yet which require strength properties higher than copper can give. Tips for resistance welders are such parts. Trolley wires make somewhat similar demands. A number of conductivity alloys offer the required combination of conductivity and strength. Chromium copper is one. Certain of the ternary beryllium alloys are others. These are important materials for resistance welder electrodes, circuit breakers, and similar parts, and have a field of usefulness where pressures are such that pure copper electrodes will not resist deformation, but which require passage of large currents. For this purpose the bronzes are not only in competition with pure copper, but with powder metallurgy products containing copper and tungsten, etc. The powder metal compacts can be prepared to permit higher working pressures, but at a sacrifice of electrical conductivity. Tungsten, however, has the important additional advantage of being "nonwelding," thus reducing tip pickup. The compacts high in tungsten are comparatively expensive.

Cadmium copper, or cadmium bronze, and the conductivity bronzes are available when high hardness and resistance to elevated temperatures are not important. They are less expensive than the preceding specialty materials. The conductivity bronzes find their largest application in trolley wires, where abrasion resistance and low cost are considerations along with high electrical conductivity. Cadmium bronze combines high strength with abrasion resistance and high conductivity, and is a heat-treatable engineering alloy especially suitable for use in the electrical field.

These conductivity bronzes offer added strength and hardness to high electrical conductivity. They have no advantage where conductivity alone is required, as in power transmission lines, for which copper or aluminum lead the field.

When requirements call for high conductivity combined with ease of fabrication, including machining and hot- and cold-working, tellurium copper may meet the need. It does not possess the hardness and abrasion resistance of the alloys already described, but instead combines high electrical conductivity with the machinability of

leaded brass. It is used for production of small machined parts for electrical equipment.

It is interesting to note that the bronzes cover such a wide range of engineering properties that they offer materials for high electrical conductivity requirements, and others with resistivity as a special property. Resistance alloys included in the engineering bronzes are some of the cupro-nickels, certain nickel silvers, copper-manganese alloys, and several of the silicon bronzes. The aluminum bronzes have fairly high electrical resistivity also, as do some of the phosphor bronzes.

The cupro-nickels are primarily high corrosion resistance alloys. They have the advantage over the stainless steels of being easier to form, and of having better heat conductivity. Their principal use is in condenser tubing for marine use, and for chemical equipment requiring easy formability. The 85-15, the 80-20, and the 70-30 alloys are sometimes used for electrical resistance purposes. When used as corrosion resistant tubing or sheeting, the cupro-nickels are fairly expensive materials.

The copper-zinc-nickel alloys known as the nickel silvers are also corrosion-resistant alloys, capable of being cold-worked to spring tempers, and, when the proper alloy is chosen, capable of being fabricated by all methods without difficulty. Its attractive appearance makes it desirable for many ornamental purposes. Moderately priced, durable, and with acceptable strength properties, it is chosen for many engineering uses also.

When intended for use as an electrical resistor, the nickel silvers, like the cupro-nickels, are best made with addition of fractional percentages of manganese, or iron, or cobalt. Magnesium has been added to the cupro-nickels (with manganese and iron). The nickel silvers most commonly used for electrical resistance are those from 12 to 30%, with fractional percentages of manganese added.

Copper-manganese alloys are effective resistivity materials, and this is their principal qualification as engineering alloys. Silicon bronzes with 2 to 4% silicon and fractional percentages of iron are electrically resistant to a degree that qualifies them for such use when required in connection with their more generally applied properties.

Bronze has been a standard material for bearings for many years, and the newer alloys have increased its usefulness for this purpose. Alloying with substantial percentages of lead confers valuable anti-friction properties upon the copper-tin combinations, esteemed for their resistance to distortion. The copper-zinc alloy known as commercial bronze is also a widely used bearing material. The bronze bearing alloys are stronger than the babbitts, and can operate at higher temperatures. They usually are chosen when the bearing must operate at high loads and velocities. In aircraft engines, the silver-surfaced shell bearings seem to give superior performance.

Graphited bearings, in which indentations filled with graphite help to protect the bronze, extend the field of usefulness of bronze bearing alloys. The high-lead tin bronzes, sometimes referred to as plastic bronzes, provide non-seizing qualities where lubrication may not always be adequate, and where service conditions are not too severe. Improved techniques in centrifugally casting alloys, and improved bearing design, made possible the use of copper-lead alloys cast in steel shells for aircraft engine bearings.

Another development in copper-tin bearing materials has been the oil-impregnated powder metal compact. These bearings have won a secure place in the automotive field.

While the specific fields of application of each type of bronze is a matter upon which opinions differ, and certainly would be considerably influenced by bearing design, the thoughts of one authority in this field are summed up as follows: Bronze bearings can be chosen where rotary, constant loads are involved. When heavy pounding loads must be carried the phosphorus-deoxidized bronzes with about 10% tin, or leaded bronzes of high tin content are preferred. For internal combustion engines and similar reciprocating applications requiring high strength, copper-lead alloys with 25% lead or higher are recommended. These alloys may contain about 3% tin or 1% silver to reduce segregation of the lead, and to increase fatigue strength. Copper-lead alloys of high lead content are suitable for use at elevated temperatures, and seem to maintain their mechanical properties up to about the melting point of the lead.

Chromium bronzes, in which hard chromium-bearing crystals are embedded in a bronze matrix, are among the new alloys in the bearing field. Performance data are not yet available in sufficient amount to evaluate their worth.

When required corrosion resistance dictates a copper alloy, and when high strength at low cost is also required, manganese bronze may be chosen. Cast or wrought alloys are available. Manganese bronze is a good general utility high strength alloy, going into such parts as studs and shafts in the wrought form and into gears and similar stressed parts in cast form. Variations in composition can be made to give the strength or working properties desired. It is not suitable for cold working.

A comparatively new alloy in the high-strength, high-conductivity group maintains its properties, including spring tempers, to temperatures above 600 F and shows only slight loss after short-time exposure to heats as high as 900 F. This is a copper-nickel-phosphorus alloy, now being used for parts in the electrical field. The material can be cold-worked, but is difficult to machine.

When fabrication of a part must include both forging and machining, and high strength and corrosion resistance are required, a new bronze containing nickel and tellurium offers a solution. Free machining qualities are obtained by use of tellurium instead of lead, so that hot workability is not lost, and strength properties are not reduced. The bronze is suitable for screw machine operations and also is heat treatable to improve strength and hardness. It can be cold worked also. Gears, bolts, and high-strength screw machine products illustrate the kind of parts for which the alloy offers advantages.

For production of nonsparking tools for use in mines, etc., beryllium bronze has almost a monopoly. It is one of the few industrial materials other than steel that can be hardened to cutting tool requirements. Hardnesses of the same order have been claimed for some of the aluminum bronzes high in aluminum and iron, but brittleness usually accompanies this high hardness in the copper-aluminum-iron composition.

Other aluminum bronzes have been used successfully for forming dies, where their hardness and the dissimilarity of die material and the metal

being formed tends to reduce seizing and pickup.

The engineering bronzes can be conveniently classified into (1) those types not hardenable by heat treatment, and (2) those compositions hardenable by such treatment. Alloys of the second group include those hardenable by phase transformation and decreased solubility, and those hardenable by solution treatment and precipitation. A difficulty arises in even this simple classification in the case of the aluminum bronzes, for those compositions containing less than about 7.5% aluminum are not hardenable by heat treatment. Because of the general similarity of properties, however, all types of the aluminum bronzes are combined in the second category.

Nonhardenable Bronzes

Silicon Bronze

Grade A silicon bronze has a general composition of: 96% copper, 3.0% silicon, 1% zinc, tin, manganese or iron. It provides highest tensile strengths and corrosion resistance equal to or better than that of copper. Grade A is weldable by all methods; has excellent hot-working properties and work-hardens rapidly when cold-worked. The work-hardened material may possess tensile strengths in excess of 100,000 psi. For most compositions lead is held below 0.05% to avoid hot-shortness. Chief uses of Grade A silicon bronze are for welded tanks, outdoor signs, cut nails, nuts, bolts, screws, chemical equipment, springs, and marine hardware piston rods. The material is available as sheet, strip, plate or rod.

Grade A silicon bronze becomes hot-short just below the melting point and should not be hot-worked above 1475 F. Annealing and similar work should be done in a non-oxidizing atmosphere, since a refractory scale of silica tends to form at high temperatures. Electrical and thermal conductivities are only about 6% of those of copper, thus favoring welding by either electrical or gas methods. Excellent sand castings are produced with sharp details. The addition of lead to 0.5% increases machinability.

Grade B silicon bronze general composition is: 1 to 2.5% silicon, 0.5 to 1.25% zinc, silver, manganese, or iron, balance copper.

This material has excellent cold-working properties, tensile strengths slightly lower than the Grade A alloys; slightly poorer weldability; corrosion resistance equal to that of copper, work-hardens to a lesser extent than Grade A. Grade B silicon bronze is available as tube, wire and rod. Its principal uses are in the manufacture of bolts, nuts, screws, condenser tubes, welding rod, conduit, etc.

Phosphor Bronze (Tin Bronze)

Alloys of copper and tin, deoxidized by adding 0.03 to 0.40% phosphorus to produce sound, dense castings are known as phosphor bronze. They are produced in several grades, with tin content increasing to about 11% and phosphorus to about 0.5%. Strength and hardness (and cost) increase with increasing tin content. In casting alloys with tin content above 5%, great care must be taken to keep reducing gases from the molten metal to avoid inverse segregation. Nonleaded grades are weldable.

The phosphor bronzes offer tensile strengths higher than that of copper, good resilience, and good fatigue resistance. Hot-workability is limited by the narrow temperature range (1150 to 1225 F) of hot plasticity, although Grade A alloys can be hot-worked to some extent from 1500 to 1650 F. Alloys containing up to approximately 8% tin have excellent cold-working properties. All grades not leaded find extensive use as welding rod for carbon arc and gas welding of many nonferrous metals, and for brazing cast iron. Leaded types have good weldability.

Typical uses of phosphor bronze include fasteners, springs, diaphragms, bridge bearing plates, contact points, etc.

The 5% tin alloy is the most used of the phosphor bronzes. It possesses good spring properties, good bearing properties and good electrical properties. Electrical conductivity falls off rapidly as tin content increases. A special high-conductivity, low-tin grade, containing 0.50% tin, has an equivalent conductivity of 40% (of copper). The approximate copper conductivity equivalent of the various grades is as follows:

0.50% tin	40%
5.00% tin	14%
8.00% tin	13%
10.00% tin	11%

The phosphor bronzes find wide use in electrical equipment because of their superior endurance and spring characteristics.

The commonly available grades of phosphor bronze are:

Grade A—5% tin
General composition: 95% copper, 4.75% tin, 0.25% phosphorus.

Grade B—leaded
General composition: 94% copper, 4.75% tin, 0.25% phosphorus, 1% lead or screw machine products.

Grade C—8% tin
General composition: 92% copper, 7.75% tin, 0.25% phosphorus.

Grade D—10% tin
General composition: 90% copper, 9.75% tin, 0.25% phosphorus.

Grade E—containing less than 4% tin for better electrical conductivity, or having other elements added for special purposes.

Grade F—containing 6% tin

A special free-cutting phosphor bronze is produced for screw machine products, bearings, bushings, etc. It consists of 4% zinc, 4% tin, 4% lead and the balance copper and is produced by several companies. It machines about as easily as free-cutting brass. Lead also improves bearing properties. It is sometimes called *bushing bronze* when provided in sheet form.

Manganese Bronze

Manganese bronze is correctly classified with the tin brasses. They are a series of high strength wrought or cast alloys deoxidized with manganese. The wrought form possesses the highest mechanical strength of all the brasses and combines with this good corrosion resistance. It has good hot-working properties but poor cold-workability and is not ordinarily so fabricated.

A general composition might be—copper, 57 to 60%; tin, 0.50 to 1.50%; lead, 0.20% max.; manganese, 0.50%; zinc, balance. Iron to the extent of 1% or more is frequently present.

The forging temperature range for manganese bronze is about 1250 to 1450 F.

Of the casting alloys, the following are typical:

High Strength (tensile 90,000 to 110,000 psi.)—62% copper, 26.5% zinc, 3% iron, 5% aluminum, 3.5% manganese.

Medium Strength (tensile 60,000 to 70,000 psi.)—58% copper, 39.25% zinc, 1.25% iron, 1.25% aluminum, 0.25% manganese.

Leaded (tensile 55,000 to 65,000 psi.)—61% copper, 35.5% zinc, 0.75% lead, 0.75% tin, 1% iron, 0.75% nitrogen, 0.25% manganese.

Commercial Bronze

Strictly speaking, commercial bronze is neither a bronze nor an engineering alloy. The material is 90% copper and 10% zinc. Its chief interest to the engineer is as a bearing material and the fact that it is not subject to season cracking nor to dezincification, and so can be used for products to be given a baked enamel finish.

Cupro-Nickels

Two types of cupro-nickels, the 80-20 and the 70-30, form the bulk of this type of alloy used. A 95-5 and an 85-15 composition are available also. The largest use of both principal types is for condenser tubes or piping for salt water piping, but bolts, nuts, screws, turbine blades, etc., are made of these alloys when severe service conditions warrant.

The 70% copper-30% nickel alloy is the more widely used type because of its greater corrosion resistance and slightly higher physicals. It frequently contains 0.50% iron and 0.50% manganese.

The 80-20 alloy continues to find use as condenser tubing where service conditions are less severe. It is lower in price than the 70-30 cupro-nickel.

Both types show the highest resistance to stress corrosion and corrosion fatigue of any of the copper-base alloys. They can be hot- or cold-formed, welded by all methods, and have excellent corrosion resistance. They are tough and rather difficult to machine. Annealing can be done at 1300 to 1600 F. Hot working is best done between 1600 and 1900 F.

Nickel Silver

A complete series of alloys with from 5 to 30% nickel comprise the nickel silvers. Grade A alloys contain three parts copper to one part zinc, while those of Grade B contain two parts copper to one of zinc. Corrosion resistance increases, not only with increase of nickel content, but also with an increase in the ratio of copper to zinc. A higher zinc content slightly lessens ductility and general workability, decreases corrosion resistance, increases electrical resistance, and favors development of spring characteristics. These grades reflect the adaptability of the single-phase or two-phase structure of the alloy to various types of fabrication.

The single-phase alloys, containing 65% or more of copper-plus-nickel, are readily cold-worked, are more difficult to hot-form, cast well, and machine fairly well. The addition of about 2% lead improves machinability. Because of high tensile strength with high modulus of elasticity, nickel silver is used extensively as a spring material. The principal use of these single-phase alloys is in the manufacture of tableware.

Two-phase alloys contain 55 to 60% of copper-plus-nickel. They possess excellent hot-working properties, and can be fabricated into intricate shapes. Lead is added to free machining grades, but these alloys are not suitable for forging.

Manganese Bronze

	Rod		*Forgings*	
	cold worked	annealed	hot	cold struck
Tensile strength, psi.	90,000	65,000	65,000	68,000

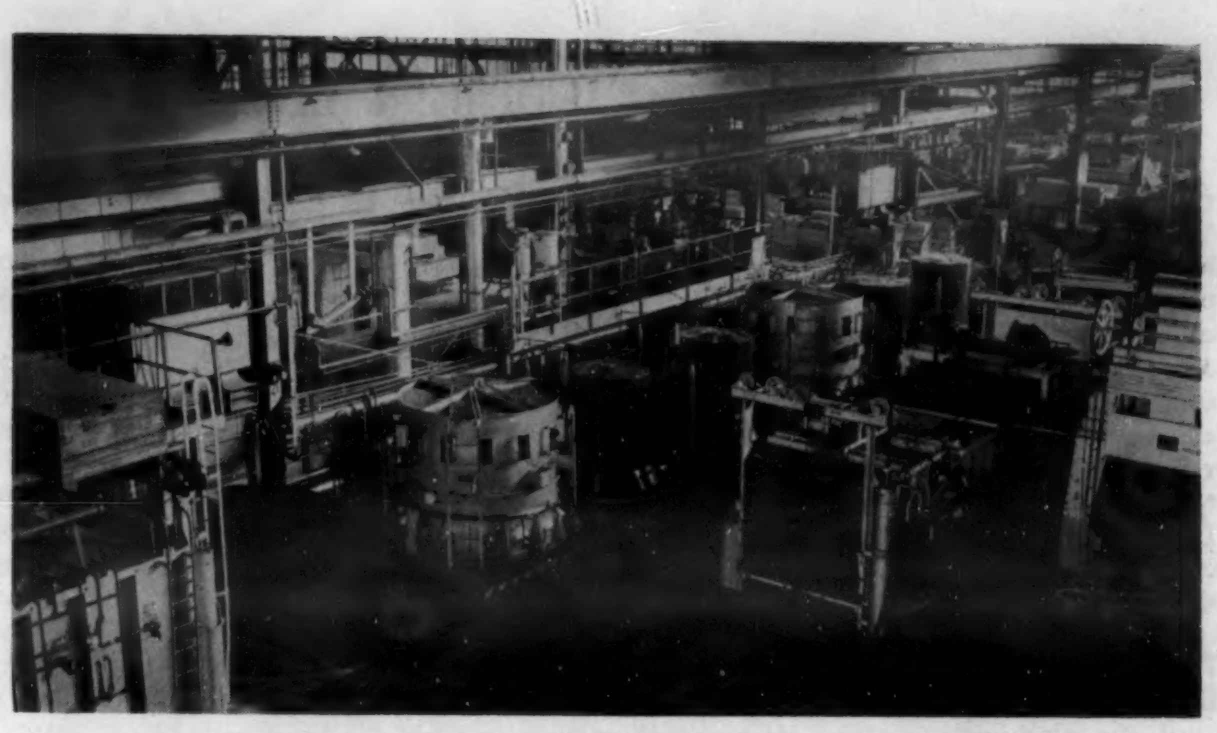
Cupro-Nickel

		Hard Drawn Rod	*Annealed Rod*	*Hot Forgings*	*Cold Forgings*
70-30 Cupro-Nickel	Tensile strength, psi.	85,000	55,000	55,000 to 60,000	60,000 to 80,000
	Yield strength, psi. (0.2% offset)	78,000	20,000	14,000 to 25,000	38,000 to 75,000
80-20 Cupro-Nickel	Tensile strength, psi.	80,000	50,000		
	Yield strength, psi. (0.2% offset)	76,000	14,000		

Nickel Silvers

	Copper	*Nickel*	*Zinc*	*Tensile Strengths, psi.* hard	annealed
5% nickel silver	62	5	33	90,000 to 104,000	51,000 to 53,000
10% nickel silver	62	10	28	101,000	52,000
10% nickel silver	67	10	23	87,000 to 103,000	50,000
12% nickel silver	66	12	22	88,000 to 102,000	52,000 to 54,000
15% nickel silver	66	15	19	85,000 to 96,000	54,000 to 55,000
18% nickel silver	62	18	20	100,000	61,000
18% nickel silver	66	18	16	84,000 to 98,000	61,000
20% nickel silver	66	20	14	82,000 to 90,000	51,000 to 54,000
20% nickel silver	75	20	5	81,000	49,000
30% nickel silver	62	30	8	94,000	59,000

Adapted from "Copper and Copper Base Alloys" Wilkins and Bunn, 1943.



The proper finish on bronze and brass strip is attained during annealing by use of bright annealing furnaces such as these. (Courtesy: Bridgeport Brass Co.)

The various alloys are named by the nickel content, and include 5, 8, 10, 12, 15, 18, 20, 21, 25, and 30% nickel silvers. The 18% nickel silver is by far the most widely used. It possesses a silvery white appearance that, combined with its excellent resistance to corrosion, recommends it for architectural uses and for parts where attractive finish is important.

For spring stock, an 18% nickel silver with high zinc content (56% copper, 18% nickel, 26% zinc) may be used. When rolled 6 B. & S. Nos. hard it develops tensile strengths of the order of 100,000 to 125,000 psi.

In the alloys designed especially for casting, zinc is held to a low percentage, about 5%. It acts as a deoxidizer and also tends to refine the gram structure and to improve workability. The casting alloys have good fabricating characteristics and can be cold or hot worked. Corrosion resistance is excellent.

Bronze Bearing Alloys and Special Bearing Materials

Several standard bronzes already mentioned are used to a considerable extent as bearing alloys. Commercial bronze is so applied, and also the leaded phosphor bronze containing 4% tin, 4% lead, 4% zinc. The latter alloy is popular for high loaded bushings, or for bearings operating under high compression loads.

A series of leaded bronzes, with progressively increasing lead content, and resulting increasing plasticity, is of importance for medium and low duty bearings. The lead content confers a non-seizing quality upon the bearing, making it especially valuable where lubrication may be imperfect, or where the journal is of soft steel that might be scored by a harder bearing material. The higher-lead members of this series are sometimes called "plastic bronzes." All are cast materials.

The 80-10-10 alloy is one of the most widely used of the leaded tin bronzes.

A second series of high-lead bearing alloys, the copper-lead group, has been developed from the plastic bronzes, but utilizes a different technique in bearing manufacture. These materials are usually bonded to a steel shell. When cast against the steel shell the whole is quickly quenched to prevent lead segregation.

Up to 2% of tin, nickel or other element, or to 1% of silver, may be added to the composition to increase hardness or reduce the tendency of the lead to segregate.

Sand or chill cast phosphor bronze, unleaded, and usually with 8 to 12% tin content, is a favored bearing material. The 10% tin content is standard, with the 8% alloy satisfactory as an economy material where service conditions permit, and the 12% alloy used where additional rigidity is required.

Tin bronzes of 14 to 18% tin content, produced as sand castings, are hard and possess little ductility. They are sometimes used as bearing materials subject to heavy compressive loads, and as bridge or turntable bearings.

Self-lubricating, or oil-impregnated, bearings are a powder metallurgy product frequently having a basic composition of 90% copper and 10% tin. Graphite is added to the powdered metals, the whole is compacted under high pressure, sintered in a protective atmosphere, and impregnated with oil. As much as 50% of the volume of such metal compacts may be voids, capable of taking up oil.

Leaded Tin Bronzes

Copper %	*Tin %*	*Lead %*	*Tensile Strength, psi.*
85	10	5	25,000 to 30,000
80	10	10	22,000 to 26,000
75	10	15	20,000 to 25,000
75	5	20	18,000 to 22,000
70	5	25	16,000 to 20,000

Copper Lead Bronzes

Copper %	*Lead %*	*Tensile Strength, psi. (app.)*
80	20	18,000
75	25	
70	30	18,000
65	35	
60	40	16,000

Hardenable Bronzes

Aluminum Bronze

The aluminum bronzes are copper-base alloys in which aluminum is the principal alloying element, and usually contain small percentages of iron, silicon, manganese, or nickel. Aluminum content may vary from about 4 to about 13%. Compositions can be divided into two broad types—those with an aluminum content above about 7.5% and heat-treatable to obtain increased hardness, and those with an aluminum content below that amount and not hardenable by heat treatment. Theoretically, a pure copper-aluminum alloy should not exhibit a beta phase until the aluminum content reaches 9.7%, but commercial aluminum bronze alloys of 7.5% or better usually show two phases.

Aluminum bronzes hardenable by heat treatment achieve this result by phase change and decreased solubility. Single-phase alloys are not hardenable by heat treatment. In general, the single-phase alloys are excellent cold-working materials with good hot workability, excellent resistance to attack by acids, and tensile strength equivalent to high brass. The duplex alloys are cold-worked with difficulty, have excellent hot-workability, increased corrosion resistance, and higher strengths. Alloys above about 11% tend to become brittle. Alkali resistance of both alloy types is poor.

In general, these alloys are used where high tensile strengths and good corrosion resistance are required. Single-phase alloys can be annealed by heating to 800 to 1400 F, depending upon properties required. Duplex alloys can be hardened by quenching in water from 1500 to 1600 F, and re-annealing at 700 to 1100 F depending upon the structure of the part as well as upon the composition of the alloy.

The 5% aluminum bronze is widely used as a corrosion-resistant tube material. It has a golden color that is utilized in costume jewelry and for decorative structural work and in tableware.

When unusually high corrosion resistance is required, as in the oil fields, or for handling brines, fractional percentages of silicon or arsenic may be added.

The 8% aluminum bronze is a binary alloy that is not hardenable. Iron to 1.5%, or manganese or nickel, may be added. The material is frequently used in "as cast" or "as worked" condition for parts requiring good resistance to corrosion and shock.

The 10% aluminum bronze usually contains several elements in addition to copper and aluminum to the extent of 1 to 4%. These can be iron, nickel, manganese, or tin. Such bronzes can be used in the "as cast" or "as worked" condition, or as annealed by the supplier. Because the alloy is about 10% lighter than other high strength copper alloys, it has been used for heavily loaded aircraft gearing and other aircraft parts, construction machinery, cams, rollers, and slides.

Several compositions in this group are more highly alloyed with analyses showing copper, 82%; aluminum, 9.5%; manganese, 1.0%; nickel, 5.0%; iron, 2.50%. Tensile strength increases according to alloy to about 105,000 psi., while attaining hardness of Rockwell 105B.

Several additional high-aluminum alloys are used occasionally. A casting alloy of 12% aluminum, 5 to 8% iron, nickel and manganese combined with the balance copper, is reported as showing good wear-resistance, and as being suitable for heavy compressive loads. A wrought alloy of 13.5% aluminum, 4.5% iron is reported as being hard enough for some nonsparking chisels and other tools.

The 5% alloy and the 10% types are the most generally useful of the aluminum bronzes. All grades are difficult to machine, and addition of lead is not advised because of its deleterious effect upon hot-workability. Use of 0.5% tellurium in the compositions has been tried by one supplier, and

	Increasing Aluminum Content			
	Alpha	⟶	*Alpha + Beta*	
Best hot working range 1350 to 1550 F	High ductility (good cold working)	decreasing ⟶	Work hardens rapidly (poor cold working)	Best hot working range 1300 to 1650 F
	Hot plasticity (fair hot working)	increasing ⟶	Excellent hot working	
	Resistance to acid attack	increasing ⟶	Good	
	Resistance to scaling or oxidation at high temperatures	increasing ⟶	Good	
	Tensile strength	increasing ⟶	High	

5% Aluminum Bronze

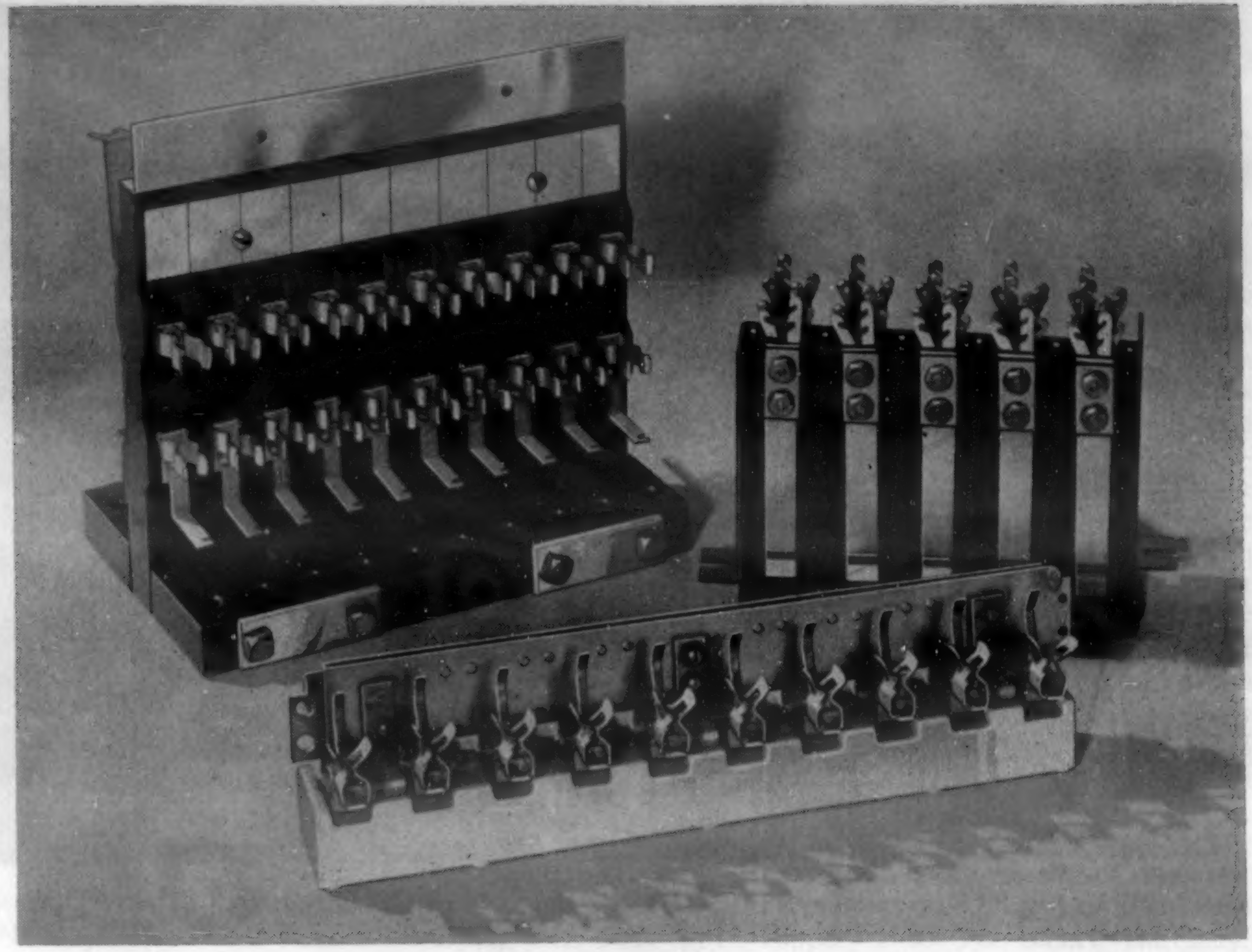
% Copper	% Aluminum	Tensile Str., psi.		Yield Str., 0.2% offset, psi.	
		cold worked rod	annealed rod	cold worked rod	annealed rod
95	5	100,000	55,000	85,000	20,000

8% Aluminum Bronze

% Copper	% Aluminum	Tensile Str., psi.		Yield Str., 0.2% offset, psi.	
		cold worked rod	annealed rod	cold worked rod	annealed rod
92	8	110,000	60,000	80,000	15,000

10% Aluminum Bronze

% Copper	% Aluminum	% Iron	% Manganese	Tensile Str., psi.		Yield Str., 0.2% offset	
				cold worked rod	annealed rod	cold worked rod	annealed rod
88.9	10	0.8	0.3	95,000	85,000	54,000	34,000



The characteristics of phosphor bronze make that material ideal for many electrical applications such as this where it is used for spring clips and contacts. (Courtesy: Riverside Metal Co.)

favorable results are reported.

These alloys are difficult to weld.

An alloy of 95.5% copper, 2.5% aluminum, and 2% tin is prepared in wire form and achieves tensile strengths to 135,000 psi. when hard drawn.

Beryllium Bronze

A group of alloys of great interest to the engineer because of their remarkable properties is the copper-beryllium series. Alloys containing about 2% beryllium are most widely used, with ternary alloys gaining in importance. They are highly corrosion resistant and capable of heat treatment by solution and age-hardening to establish high mechanical properties. Because of the high cost of the material, its greatest use has been in the fabrication of small parts of high value. It is the best corrosion-resistant spring material available at present. Beryllium bronze springs show a remarkable freedom from hysteresis and elastic drift.

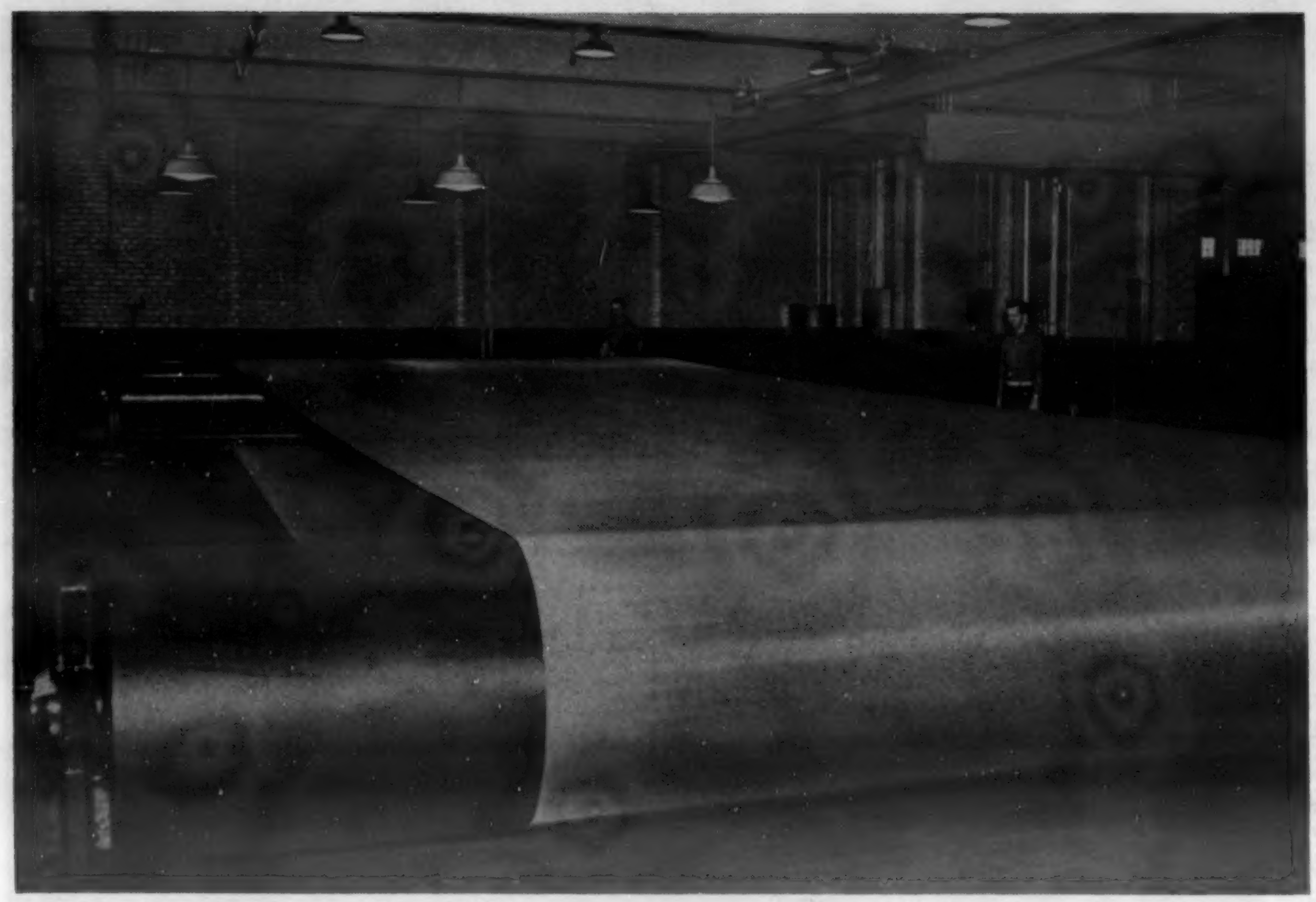
In the fully heat treated condition, beryllium bronze has better wear resistance than phosphor bronze and finds use in manufacture of heavily loaded bushings, commutator segments, contact clips, etc. While tensile strength in the annealed or solution treated condition is of the order of 70,000 psi., precipitation hardening will increase this strength to about 200,000 psi., and hardness values as high as Rockwell 41C.

The alloy containing 2% beryllium, one of the most versatile of the beryllium bronzes, can be taken as typical of the useful binary alloys. It has a density of 8.23 and shows a very slight negative magnetic susceptibility.

Beryllium bronze is usually furnished in the solution treated condition, often termed annealed, or may be offered with a stated amount of cold-working done upon it. When material is intended for springs, a given amount of cold work is specified, as the highest physical properties can then be obtained in the fully heat treated parts. The solution treatment consists of annealing at 1475 F for at least 2 hr., preferably 3 hr., and quenching immediately in cold water. The material can now be machined or cold-worked, or hot-worked in the range 1090 F to 1425 F. It can also be welded, brazed, or silver soldered. When selecting a silver solder for this work, it is important that it melt and flow freely at a temperature below the melting point of the bronze (1587 F) and at the same time solidify at a temperature above the quenching heat of 1440 F. If the material has been cold-worked and has hardened so much as to pre-

Beryllium Bronze

	Thermal conductivity at 68 F	*Electrical conductivity, 20 C*	*Electrical Resistivity*
Soft or hard drawn	0.14 to 0.16 B.t.u./sq.ft./in./sec./F	17% of copper equivalent	60 ohms/mil ft.
Precipitation hardened	0.16 to 0.20 B.t.u./sq.ft./in./sec./F	18 to 25% copper equivalent	41 to 59 ohms/mil ft.



Phosphor bronze is used for warp and shute wire in Fourdrinier screens for paper making. This one measures 234 in. by 80 ft. (Courtesy: Riverside Metal Co.)

vent further work, or if it has been hot-worked at the forging temperatures, or if welding or soldering operations have been performed, the part should be annealed. Heating to 1475 F, holding at that temperature for 15 to 30 min., and quenching immediately in cold water softens the alloy.

To obtain highest physicals, the bronze can be work hardened before the precipitation treatment.

Heat treatment is completed by the precipitation hardening, in which the bronze is held at a definite temperature, between about 480 F and 650 F, for the required time which is from 1 to 2 hr.

Since temperatures in the range of 500 F and higher gradually affect the structure of beryllium bronzes, they are not suitable for service conditions involving such temperatures.

The modulus of elasticity of beryllium bronze is 17,000,000 to 19,000,000 psi., while that for steel is 29,000,000 psi. Therefore, when substituting a beryllium bronze spring for one of steel, the gage of the bronze should be increased slightly over that for steel if the same load deflection characteristics are desired.

In the ternary alloys, use of up to 0.5% nickel in 2% beryllium bronze is made to control grain size and to increase elongation. Nickel serves as a minor alloying element in this case. However, there are several true ternary alloys involving beryllium and copper, using cobalt, chromium, zirconium, titanium, and nickel as a third element. Most of these precipitation-harden at higher temperatures, in the 840-930 F range, and so retain their properties at higher service temperatures. The alloy 97% copper, 0.4% beryllium, 2.6% cobalt is a heat-treatable casting alloy with over 45% equivalent conductivity. It finds use in resistance welding electrodes, etc. Prepared in wrought form the conductivity is slightly higher. Service temperatures to about 800 F can be used.

Results of Working Beryllium Bronze

	Tensile Str., psi.	*Yield Str., 0.5% elongation, psi.*	*Rockwell hardness, C scale*
Annealed, precipitation hardened	150,000 min.	90,000	33 min.
Cold worked quarter hard, precipitation hardened	160,000 min.	92,000	35 min.
Cold worked half hard, precipitation hardened	170,000 min.	93,000	37 min.
Cold worked hard, precipitation hardened	180,000 min.	95,000	39 min.

Chromium Bronze

A heat-treatable material offered in cast or wrought form and presenting interesting properties is chromium copper, or chromium bronze. The wrought alloy contains 99 to 99.5% copper with 0.5 to 1.0% chromium, to which may be added 0.1% silicon. In the heat treated condition properties will be:

Tensile Strength, psi.	*Yield Strength, psi.*	*Hardness, Rockwell*	*Electrical Conductivity*
72,000	63,000	B77	80% or better

In cast form the composition is es-

sentially the same, with 0.4 to 0.8% chromium, and deoxidants. Tensile strength is lower, about 45,000 psi. being acceptable, while electrical conductivity remains above 80% equivalent copper.

The alloys are precipitation hardening. Solution treatment may consist of quenching from about 1800 F, and a subsequent aging at about 900 F for 6 to 8 hr. will harden the bronze. The high conductivity is arrived at only after heat treatment, the conductivity before treatment being about 40%.

Chromium copper retains its high conductivity at elevated temperatures and can be used at temperatures to about 700 F. It finds application in resistance welding electrodes, circuit breakers, commutator switches, etc.

Cadmium Bronze

Cadmium bronzes offer a combination of high strength, good abrasion resistance, high electrical conductivity, and moderate price. They are heat treatable wrought alloys consisting of 99% copper with 0.4 to 1.0% cadmium. One alloy adds 0.60% tin, with slightly higher strength but lower conductivity. Some physical properties given for wire are:

% Copper	% Cadmium	Tensile Strength, psi.	Electrical Conductivity
99.0	1.0	90,000	89%
98.6	0.80 0.60% tin	95,000	61%

British manufacturers claim conductivities as high as 92% for their cadmium bronzes.

Tellurium Copper

A new material with interesting fabricating possibilities is tellurium copper, an alloy of 99.5% copper and 0.5% tellurium. Tellurium has been added to several of the bronzes to impart free machining qualities without making the material unsuitable for hot-working, and it accomplishes the same effect with copper. Tellurium copper has excellent electrical conductivity, is forgeable, weldable, and free machining. It can be cold-worked readily. Forging temperatures are 1400 to 1600 F.

The alloy is being used for fabricating parts in the electrical and radio industries, such as contact pins, inserts in multiple contact assemblies, etc., and for such parts as welding and cutting tips, where thermal conductivity is important.

Heat treatment consists of a solution anneal, leaving the parts soft and suitable for cold working, and an aging treatment. For the solution treatment the work is quenched or cooled rapidly from 1400 to 1500 F. When a cold-working operation follows, the aging treatment consists of heating for from 1 to 3 hr. at 775 F. When no work has been done the temperature for the aging treatment is increased to 850 F.

The alloy is being used for bolts, nuts, screws, high strength screw machine parts, etc.

Nickel-Phosphorus Bronze

A heat-treatable bronze combining high strength with high electrical conductivity, nickel-phosphorus bronze is being utilized for electrical applications, for rivets, screws, cold-punched nuts, etc. It can be cold-worked readily in the solution annealed condition, and after aging can be drawn to a spring temper. It is difficult to machine. Electrical conductivity is 60% in the heat treated condition, and 50% in the hardest spring tempers. Tensile strengths can be increased to as much as 120,000 psi. by cold working after aging. Spring tempers are substantially maintained at temperatures of 500 to 600 F.

Heat treatment consists of quenching in cold water from 1400 F for the solution anneal, and aging 1 to 4 hr. at 850 F.

Cast Tin Bronzes and Bell Bronzes

Tin bronzes with tin content of 15 to 25% can be heat treated, and hardened by phase transformation. These alloys are hard and brittle, and transformation rates are so slow that heat treatment is rarely practical. As much as 15 to 25 hr. may be required in the furnace.

Nickel Bronzes

A precipitation-hardening alloy with 70% copper, 29% nickel, 1% tin is available. Cast bronzes of 5 to 8% tin and 1.5 to 8% nickel have been developed that cast well and can be hardened by heat treatment. A solution treatment at 1400 F for 5 hr., a water quench, or air cooling where the size of the work is suitable, and an aging treatment at 550 to 600 F for 5 hr. develops full properties.

A series of nickel-silicon alloys of copper is reported from Great Britain as suitable for elevated temperature use. A 98 to 99% copper, 0.5 to 1.0% nickel, 0.5 to 1.0% silicon composition gives tensile strengths of 50,000 psi. in the heat-treated condition and is used in locomotive fireboxes. A higher-alloyed material consists of 96 to 97% copper, 2 to 3% nickel, and 0.5% silicon, and offers tensile strengths to 90,000 psi.

A heat-treatable casting alloy, capable of giving over 40% electrical conductivity, has the composition 97% copper, 2.5% nickel, and 0.5% silicon.

Miscellaneous Conductivity Alloys

A castable conductivity alloy giving about 40% electrical conductivity has a composition 97% copper, 2.5% cobalt, 0.5% silicon. Tensile strengths in the heat-treated condition are re-

Tellurium Copper (Typical Properties)

	Tensile Str., psi.	Yield Str., psi.	Rockwell Hardness	Electrical Conductivity
Hard drawn rod	72,000	62,000	B84	50%
As forged	36,000	10,000		
Aged after forging	58,000	38,000	B70	50%

Nickel-Phosphorus Bronze

	Tensile Strength, psi.	Yield Strength, 0.2% offset, psi.	Electrical Conductivity
Aged	65,000	40,000	60%
Half hard	88,000	78,000	60%
Hard	97,000	85,000	59%
Special spring	120,000	105,000	50%

ported to be in the neighborhood of 90,000 psi. This alloy is said to have better casting properties than the cobalt-bearing beryllium bronze for which it is sometimes substituted.

A copper-iron-phosphorus alloy, precipitation-hardenable, is noted as gaining in favor for electrical applications.

Electrical Resistance Alloys

Copper-Manganese Alloys—A series of compositions containing copper and manganese, with fractional percentages of iron, show electrical resistance values sufficiently high to qualify as resistance materials. Alloys with from 90 to 70% copper, remainder manganese and small quantities of iron, possess resistivities of from 35 to 100 microhms per c.c., resistivity increasing in general as copper content decreases. When highest resistivities are to be obtained the quenched alloys are reheated to about 1100 F for final heat treatment. The wires are ductile.

Nickel Silvers—The nickel silvers with from 10 to 30% nickel show resistivities of from 20 to 38 microhms per c.c. when 0.10 to 0.15% manganese is added to the standard compositions. Operating temperatures should not be above 700 F.

Silicon Bronzes—The grade A silicon bronzes possess resistivities of the order of 25 microhms per c.c.

Cupro-Nickels—Alloys of the 80-20 and 70-30 types of cupro nickels, with 0.10 to 0.30% manganese and fractional percentages of iron, show resistivities of about 25 to 35 microhms per c.c.

Fabricating the Engineering Bronzes

Fabricating possibilities for the engineering bronzes cover a range as wide as that of the compositions of the alloys or of their applications. These have been outlined under each alloy. Some are free machining, others are machined with difficulty; some can be cold- or hot-worked, others are more limited. Having listed the specific possibilities of each composition, the fabricating operations can be considered in more detail.

Machining

Pure copper, of low hardness but very tough, is quite difficult to machine. The tin bronzes are likewise tough and difficult to machine. Addition of lead to the bronzes greatly improves machinability, but makes them hot-short, and difficult to weld. Addition of tellurium also improves machinability, permits hot-working, and does not greatly lower electrical conductivity, but tends to wear the cutting tools more than the leaded alloys.

Cutting tools may be of carbon tool steel, high speed steel, or carbide-tipped types. Where runs are short, or where other factors dictate against the higher-priced tools, the carbon steels can be used. They are limited to lower cutting speeds.

High speed steel tools will permit higher rates of production, and are to be desired for turning, drilling, tapping, reaming, milling, and for form tools. The gain in production is especially noticeable in the case of lathe tools. High speed steel tips brazed to carbon steel shanks reduce the cost.

Carbide-tipped tools are frequently used for high production, especially when castings or large diameter work pieces are being machined. They afford the greatest savings when comparatively large amounts of metal must be removed. Since tool wear is lower, they produce better finishes and hold closer dimensions, while saving time for tool grinding and setting.

When machining the bronzes, use of the highest practicable cutting speed with a moderate depth of cut and a relatively light feed is good general practice. However, when castings are being machined with carbon or high speed steel tools a low turning speed, with a depth of cut sufficient to get under the surface scale over the entire circumference, and coarser feed are recommended to avoid the abrasive action of the scale. The scale is retained to some degree on sand castings even after tumbling or pickling. When carbide tools are used on castings the initial cut can usually be made at the same speed as the semi-finish cuts.

Free machining bronzes, including commercial bronze, low-nickel leaded nickel silvers, tellurium copper, leaded bearing bronzes, and tellurium-nickel bronze, can be turned with high speed steel tools at about 300 to 700 surface ft. per min., with feeds of about 0.006 to 0.020-in. for roughing cuts, and 0.003 to 0.015-in. for finishing cuts. Rake angles are reduced for these easily machined alloys to prevent "digging in." Back rake may be held to 0 and side rake to 0 to 3 deg. with front clearance of about 6 deg., 0 to 5 deg. side clearance, and a lead angle of 10 to 15 deg. Cutting speeds should be reduced to about half those given if carbon steel tools are used. For large work, or for parts being machined in large boring mills, the lower limits of cutting speeds should be used.

Bronzes of medium machinability include the manganese bronzes, leaded nickel silvers with medium nickel content, leaded phosphor bronzes, and silicon bronzes. They may be cut at about 150 to 300 surface ft. per min., with feeds of about 0.015 to 0.035-in. for roughing cuts, and 0.005 to 0.015-in. for finishing cuts. Rake angles may be 5 to 10 deg. for back rake, the same for side rake, and front clearance 6 to 15 deg., side clearance 5 to 10 deg., and lead angle 10 to 15 deg. As before, cutting speeds for carbon steel tools should be about half those given.

Hard to machine bronzes include the phosphor bronzes, nickel silvers, cupro-nickels, aluminum bronzes, beryllium bronzes, and chromium bronze. They can be turned at about 75 to 150 surface ft. per min., with feeds of about 0.015 to 0.040-in., for roughing cuts, and 0.005 to 0.020-in. for finishing cuts. Turning tools may be ground with rake angles of 10 to 20 deg. back rake, and 20 to 30 deg. side rake. Front clearance can be 10 to 15 deg., side clearance 10 to 20 deg., and the lead angle 15 deg. The same precaution to reduce speeds should be taken if carbon steel tools are used.

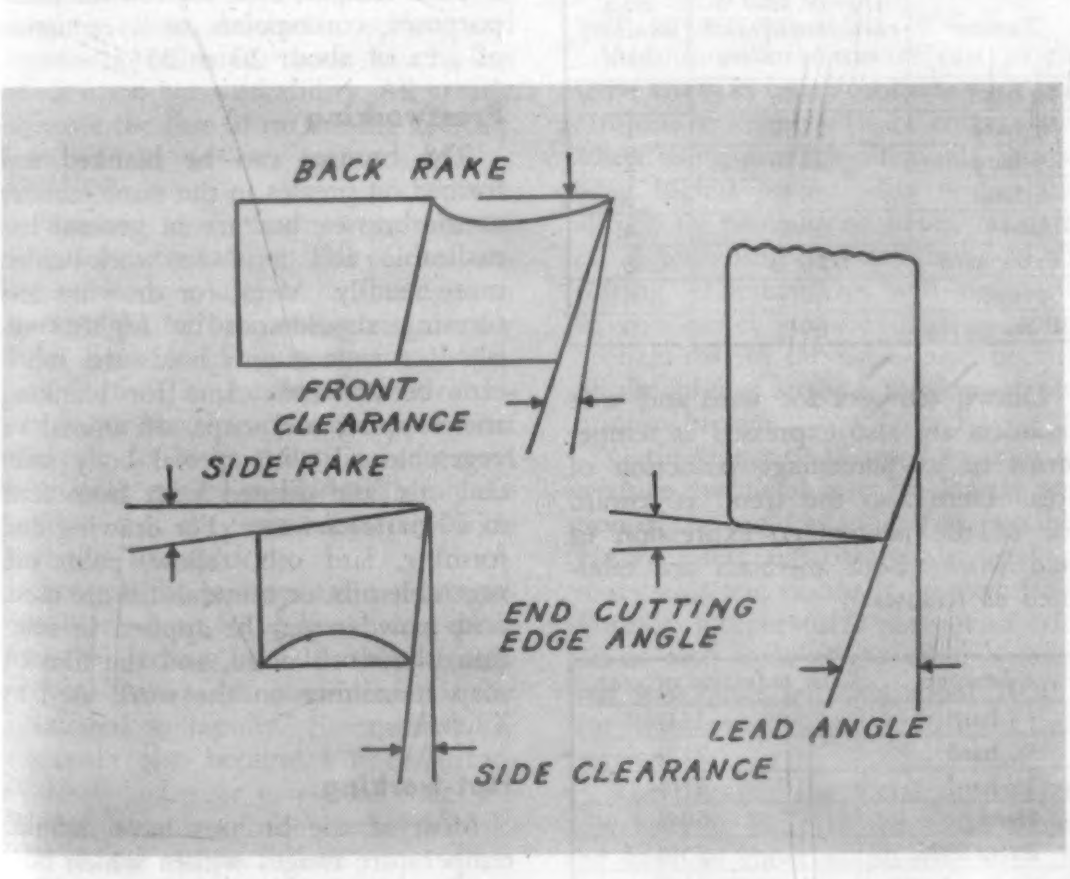
Carbide-tipped tools permit greatly

increased cutting speeds in turning the bronzes, and offer important savings in machining time. They are best used with a comparatively light feed and rather heavy depth of cut. Tool and machine must be rigid and free from backlash and play.

For free machining bronzes cutting speeds should be from 400 to 800 surface ft. per min., and feed 0.015 to 0.025-in. for roughing cuts, and 500 to 1000 surface ft. per min., and 0.005 to 0.015-in. for finishing cuts. Bronzes of medium machinability can be cut at 300 to 500 surface ft. per min. with feeds of 0.015 to 0.030-in. for roughing cuts, and 400 to 600 surface ft. per min. and 0.005 to 0.015-in. for finishing cuts. Hard to machine bronzes can be turned at 250 to 600 surface ft. per min., using feeds of 0.015 to 0.030-in. for roughing cuts. Finishing cuts may be made at 300 to 800 surface ft. per min., with feeds of 0.008 to 0.015-in.

Carbide tools should be kept sharp, and rake and clearance angles should be held closely. When the operation permits, the nose radius on the tool should be held to a minimum, usually 1/32 to 1/16-in. Excess rake and clearance tend to weaken the cutting edge.

Carbide tools to be used for cutting free machining bronzes can be ground with no back rake, and with 2 to 6 deg. side rake. Front clearance can be 4 to 6 deg., and side clearance the same. The lead angle might be about 10 to 15 deg. For medium machining bronzes 0 to 5 deg. back rake and 4 to 8 deg. side rake may be used, with front clearance and side clearance also 4 to 8 deg., and the lead angle about 10 to 15 deg. Hard to machine bronzes can be cut with the tool ground to 4 to 8 deg. back rake, 15 to 25 deg. side rake, 7 to 10 deg. for both front and side clearance, and the lead angle 10 to 15 deg.



Angles and clearances to consider on turning tools when machining engineering bronzes.

Drilling

When high production is desired in drilling operations drills of special design are available. The slow spiral drill, intended for work with brass, has a helix angle ranging from 10 to 22 deg. instead of the 26 to 30 deg. in the standard drill. It has a thin web, providing large chip clearance. These drills are often used for deep hole drilling and for screw machine work with the free machining and medium machining bronzes. For hard to machine bronzes and for copper, high spiral drills having a helix angle of about 40 deg. are more successful.

Cutting edges on the drills should be flattened when drilling free machining and medium machining bronzes, but not when working with those alloys difficult to machine. Speeds of 200 to 500 ft. per min. are common with free machining types, 75 to 250 ft. per min. with the medium machining alloys, and 50 to 125 ft. per min. for the difficult materials. Feeds for drill sizes from about 1/8 in. to 3/4 in. are about 0.003 to 0.020 in. per revolution. These values are intended for high speed steel drills. With carbon steel drills speeds should be about half those given.

All standard types of reamers can be used on the bronzes when correctly ground, but best results are obtained with spiral flute reamers with a helix angle of 7 to 12 deg. Chatter is reduced, and smoother finishes result. Left-hand spiral, right-hand cut reamers are most successful. Reamers should be ground with 0 deg. rake angle for free machining bronzes, and with about 3 to 6 deg. back rake for the more difficult to machine alloys. Clearance of 6 to 8 deg. is suggested for all alloys.

When reaming free machining bronzes with high speed steel reamers, cutting speeds to about 200 ft. per min. can be used. Alloys of medium machinability require speeds of 75 to 150 ft. per min., while the difficult alloys are worked at 60 to 90 ft. per min. Feeds are approximately two to three times those used for drilling. Machining speeds should be reduced to about half these values when using carbon steel reamers.

Tapping

When holes in the bronzes are to be tapped, it is important that the correct tap drill be used. A drill size sufficiently large to provide a little clearance at the root diameter will greatly reduce the power required for tapping, and also reduce breakage of taps.

For free machining alloys, taps should be ground with 2 to 4 deg. rake angle, or "hook." The medium machining types are best tapped with 5 to 8 deg. rake angle ground on the tap. For the more difficult alloys, and for copper, an 8 to 15 deg. rake angle gives good results. Taps for use with these last alloys do best if a 10 to 15 deg. chamfer is ground on the first two or three threads, and a spiral point ground on the flutes.

Alloys in the free machining group

can be tapped at speeds of about 150 to 250 ft. per min.; the medium machinable group at about 60 to 150 ft. per min., and the others at about 30 to 60 ft. per min.

Milling

The engineering bronzes can be milled with practically all ordinary types of milling cutters. Adequate clearance behind the cutting edges should be provided to prevent rubbing. Too much clearance or rake will be shown in operation of the milling machine by a tendency of the cutter to dig into the work, or by excessive vibration. Excessive cutting speed produces the same tendencies.

Spiral cutters with a helix angle of 20 to 30 deg. and helical cutters with 50 deg. helix angle resist the tendency to dig in, and give fine finishes with all the bronzes. Width of the land should be held to a minimum.

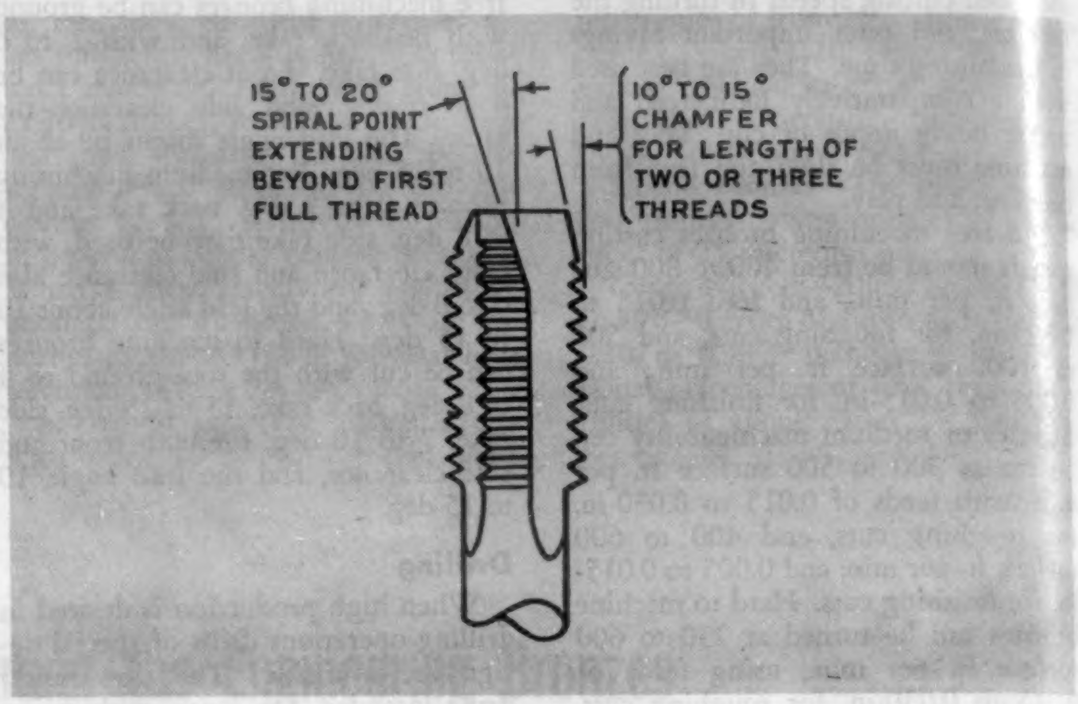
Cutting speeds will be greatly influenced by the type of work, type of machine, width and type of cutter, and rate of feed. Speeds can be given as as generalized guides only. The free machining bronzes can be cut at from 200 to 250 ft. per min., the medium machining alloys at from 150 to 200 ft. per min., and the difficult to machine types at from 50 to 150 ft. per min.

Cold Working

Cold working operations include drawing, forming, rolling, stamping, spinning, bending, and heading. No essential similarity exists among these operations, so that only a broad and generalized statement can be made about cold workability, as "good," "fair," or "poor." The alloys have been designated as to cold workability in the preceding section.

An important feature of cold working is the possibility of work-hardening materials not otherwise hardenable. Since the degree of work hardening can be calculated and controlled, it is possible to fabricate a part by such methods so that it will have definite mechanical properties when completed. Work hardening can be determined only for each individual design, except in the case of such simple forms as springs, wires, and similar shapes.

Rolled tempers on flat pieces are expressed as percentage reduction, or by such terms as quarter hard and half hard. The percentage reduction is in more general favor at present, and all reductions in excess of 60% are given as percentages.



This tap is ground for use on the more difficult alloys and copper. In tapping, care should be taken to use the proper size tap drill.

The relationship between these designations is:

Temper	*Approx. final % reduction of thickness by rolling*	*B&S numbers hard*
⅛ hard	6%	
¼ hard	11%	1
½ hard	21%	2
¾ hard	29%	3
Hard	37%	4
Extra hard	50%	6
Spring	60%	8
Extra spring	69%	10

Drawn tempers for wire and wire products are also expressed as temper terms or as percentage reduction of area. Here also the trend is toward use of the percentage expression of cold work. Both methods are tabulated as follows:

Temper	*% reduction of area*
⅛ hard	11%
¼ hard	21%
½ hard	37%
Hard	60%
Extra hard	75%
Spring	84%
Rivet	about 6%
Screw	about 15%

Drawn rod, bar, and tube tempers are usually expressed in terms of temper as ¼-hard, ½-hard, hard, and occasionally extra hard. The exact reduction of area cannot be expressed in a simple tabulation.

Drill temper, used for rod for many purposes, corresponds to a reduction of area of about 20 to 25%.

Pressworking

The bronzes can be blanked and formed on presses in the same manner as the brasses, but are in general less malleable and tend to work-harden more readily. Metal for drawing and forming should not be highly polished; a matte finish holds the lubricant better. Lubricants for blanking and cupping are soaps, of animal or vegetable oil with special body mineral oils, and diluted with from four to 20 parts of water. For drawing and forming, lard oils, tallow, palm oil, vegetable oils, or mineral oils are used. Soap powder may be applied in solution, the work dried, and the film of soap remaining on the work used as a lubricant.

Hot-working

Most of the bronzes have definite temperature ranges within which hot-working can be done, and these ranges should be adhered to closely in forging, hot pressing, or extruding the

alloys. Many are subject to hot-shortness at temperatures close to the melting point. In general, hot-working ranges are narrower than for the steels and for most other metals.

Hot-working ranges have been given for most of the bronzes that are considered as hot-working materials. Rating of hot workability would depend upon the power required to hot work a given material, the hot-working range, and adaptability to the various types of forging and other hot-working methods. The rating can be given in only general terms, such as "good," "satisfactory," or "poor."

The excellent quality of the parts produced by hot-pressing has made this type of forging extremely popular in recent years. The work is dense, sound, and possesses good surface texture. Forgings in general can be machined easier than cast parts because of the freedom from adhering sand and hard surface scale. It has been estimated that from four to six times as many forged parts can be machined per tool setup as is possible with sand castings.

When work that has been formed by forging requires considerable machining to finish, a composition containing sulfur, selenium, or tellurium may be of advantage. While lead makes the bronzes of little value as forging alloys, selenium, sulfur, and especially tellurium have much less effect upon hot-workability. All greatly increase the ease of machining bronzes.

Casting

Bronzes lend themselves well to fabrication by casting. All of the casting methods in use in the foundry can be applied to bronzes—green or dry sand, floor molding, centrifugal, precision, etc. The casting procedure depends so greatly upon the design of the part to be cast that only general principles can be mentioned, with the caution that they are subject to wide variation in practice.

Because the bronzes are cast at temperatures about 500 F lower than those for the ferrous metals, they usually require finer sands, since steam is not generated so rapidly. Finer sands are necessary also because a finer surface is desired. Larger gates and risers are needed because of the greater shrinkage of the copper alloys.

Since copper, quite resistant to oxidation at ordinary temperatures, is rapidly attacked as it approaches its melting point, a cover—frequently charcoal—is usually maintained over the molten metal. Borax, soda ash, glass or lime and fluorspar are also used. Phosphor copper serves as a deoxidizer, in amounts of 6 to 8 oz. per 100 lb. of metal, or 1 lb. per 100 lb. if phosphor bronze is being produced.

For phosphor bronzes, gates are made slightly heavier than for the red brasses. Melting is accomplished as rapidly as possible, and super-heating and soaking are avoided. Pouring temperatures of 1950 to 2250 F are generally satisfactory, and the temperatures before pouring should not rise more than 100 F above the pouring temperature if coarse grain is to be avoided.

When high-lead bronzes are to be cast, a sand of AFA Fineness No. 150 to 230 is suggested, unless a facing material is to be used, since these alloys penetrate the sand deeply. Molds must be well vented. A facing of plumbago is helpful. These alloys have a long cooling range, and are subject to porosity.

Pouring temperatures depend upon composition, and even for a given alloy they are influenced more than ordinarily by the nature of the mold and size of the casting. Temperatures may be within the range 1850 F to 2200 F, with an average about 2050 F.

Aluminum bronzes are cast in the same sands as other bronzes, with precautions to keep moisture content low when using green sand molds. Somewhat higher permeability is desirable also, both precautions being taken to avoid pinholing and scumming of the casting. These alloys will ordinarily have a better surface than phosphor bronzes cast in the same sand, because of the higher surface tension of aluminum bronze.

Gating must be planned so as to introduce the metal into the lowest portion of the mold as quietly as possible. Heavy risers are commonly used, so that yields will normally be over 50%. Pouring temperatures are not as critical as with some of the other bronzes, but will range between about 1950 F for heavy castings and 2250 F for light sections.

The distance the metal drops from the pouring ladle to the mold should be kept as short as possible and the gate should be kept filled to avoid drawing dross into the mold.

Silicon bronze casting requires careful sand control. Sands should have an AFA grain size of 140 to 200, a permeability of 15 to 39, and a moisture content not exceeding 6%. Silicon bronzes have a shrinkage less than that of the aluminum bronzes, but higher than for the phosphor bronzes. Gating practice should be about the same as that for the latter alloys. Risering should be so located that the last metal to enter the mold will be in the risers.

The metal should not be superheated, and pouring temperatures should be as low as will enable the metal to fill the mold completely. For small castings or thin sections, this may be 2100 to 2150 F. Small to medium castings are poured to 2000 to 2050 F, while large castings, and those having simple forms, may use 1900 to 1950 F.

Nickel silvers, leaded and unleaded, require careful attention to sand selection. Good refractory qualities are needed, and moisture should be kept low, not above 6%. Skin-drying is helpful. Kerosene or fuel oil can be used for swabbing or patching, and flour or plumbago are sometimes used as facing materials.

Liberal gates and risers are necessary because of the high shrinkage of the nickel silvers. The risers should take the last metal to enter the mold. Careful locating of gates and risers is important, and should be carefully planned for each design.

Pouring temperatures can range from 2050 to 2350 F for heavy castings to 2300 to 2600 F for light castings, depending upon the alloy used.

Manganese bronzes have good castability, but high shrinkage requires careful consideration of gating and risering. Sand selection is not critical, but moisture should be kept low. The mold can be filled by simple displacement, using bottom pouring or any other method that will keep agitation to a minimum.

When manganese bronze is being alloyed at the foundry, it is customary to make up a hardening alloy first, melting the manganese, aluminum and iron with an amount of copper sufficient to give an alloy capable of ready solution in copper. The hardening alloy is poured into slabs or ingots for remelting. Copper is then melted and the correct amount of hardening alloy added, followed after its complete sol-

ution by the required amount of zinc. The alloy is then thoroughly stirred, and poured into the molds, or into ingots for remelting.

Before pouring, the metal is brought up to a temperature at which it shows a slight flare. This may be 1850 F with low strength bronzes, or about 1950 F for high strength metals. Pouring should take place at the highest temperature possible without attempting to pour during flaring.

Forms and Finishes

A "drawn flat product," by definition of the Copper and Brass Research Association, is a solid section of relatively great length in proportion to its thickness, having two plane parallel surfaces and two longitudinal edges, both planes and edges brought to final dimensions by drawing through a die. A "drawn bar" is a flat product over 3/16-in. thick and to and including 12-in. width. A "drawn strip" is between 0.003-in. and 3/16-in. thick and to 20-in. wide, while "drawn flat wire" is of the same thickness but to 1¼-in. width. A "rolled flat product" is the same solid brought to its final dimensions by rolling, with edges unfinished or brought to final width by slitting, shearing, sawing, or by rolling to various contours. The type of edge should be indicated. "Rolled flat wire" meets the dimensions of drawn flat wire; "rolled strip" and "rolled bar" parallel the drawn products. "Foil" is a rolled flat product up to and including 0.003-in. in thickness; "plate" is rolled over 3/16-in. thick and over 12-in. wide; while "sheet" is rolled from 0.003 to 3/16-in. thick and over 20-in. wide.

"Rod" is a round, hexagonal, or octagonal solid section furnished in straight lengths. If brought to finished dimensions by drawing through a die it is drawn rod; if finished by extruding, extruded; if extruded and subsequently drawn, extruded and drawn rod. "Cold rolled rod" is brought to finished dimensions by cold rolling, "hot rolled rod" by hot rolling, and "turned rod" by machining. A solid section other than round, hexagonal, octagonal, square, or rectangular, furnished in straight lengths, is a "shape."

A "tube" is a hollow product of round or any other cross-section, having a continuous periphery. "Pipe" is seamless tubing conforming to standard pipe sizes, "seamless tube" indicating that it was made with a continuous periphery at all stages, in contrast to brazed, welded, open-seam, and lock-seam tube. A tube of non-uniform wall thickness, or of irregular periphery, or both, is a "tubular shape."

Sizes are now given in terms of nominal dimensions rather than in gage sizes. Diameters of wire are given in decimals of an inch. Weight per piece or per unit of length or of area can be used for large plates or other forms.

Round wire in coils is supplied in diameters to 0.060 in. (No. 4/0 B&S); square, hexagonal or octagonal, minimum dimension, 0.050 in., maximum, ⅜ in.; flat, from 0.016 in. to 0.250 in. thick, and 0.032 to 0.750-in. wide.

Mill finishes include plain pickled finish, produced by immersion in sulfuric acid, and duller in appearance than the bichromate finish; bichromate dipped finish, giving a nearly complete removal of scale and oxide; bright dipped finish, obtained by final immersion in oxidizing acids, and giving complete removal of scale and oxide; cold rolled finish, obtained by cold rolling the pickled metal with a lubricant; kerosene rolled finish (or soap rolled or soluble-oil rolled), a semi-burnished finish obtained by cold-rolling with kerosene; dry rolled finish, in which no lubricant is used during rolling, giving a burnished appearance; acid dipped, dry rolled, in which the bichromate or acid dipped metal is dry rolled, giving a burnished appearance; hot rolled, a dark, rough finish obtained by hot rolling (subsequent dipping may brighten the surface, but it remains slightly rough); drawn finish, a smooth and bright appearance obtained by drawing through a die; piston finish, made by grinding or turning to close tolerances; oxidized finish, remaining after annealing unless followed by pickling or dipping; extruded finish, slightly oxidized and dull following hot extrusion; scratch brushed finish (satin finish), resulting from mechanically brushing the surface with a wire bristle brush or by buffing with a greaseless compound; polished surface, a high gloss resulting from buffing with rouge or a similar polishing agent; and bright annealed finish, obtained by annealing in a protective atmosphere.

In addition to the above, various color finishes, such as Bronze, Antique, Old English, Pompeian, Blue Black, Matte, Brown, or platings—as electrotinned or dip tinned—can be obtained.

Acknowledgment

The following producers of brasses and bronzes assisted in the preparation of this manual:

American Brass Co., Waterbury, Conn.
American Manganese Bronze Co., Philadelphia
Ampco Metal, Inc., Milwaukee, Wis.
Bridgeport Brass Co., Bridgeport, Conn.
Briggs Mfg. Co., Cleveland, Ohio
Bristol Brass Corp., Bristol, Conn.
Chase Brass & Copper Co., Waterbury, Conn.
Cramp Brass & Iron Foundries, Eddystope, Pa.
Wilbur B. Driver Co., Newark, N. J.
Frontier Bronze Corp., Niagara Falls, N. Y.
Little Falls Alloys Co., Paterson, N. J.
P. R. Mallory & Co., Inc., Indianapolis, Ind.
McGill Mfg. Co., Inc., Valparaiso, Ind.
Mueller Brass Co., Port Huron, Mich.
New Haven Copper Co., Seymour, Conn.
Phosphor Bronze Smelting Co., Philadelphia
Revere Copper and Brass, Inc., New York
Riverside Metal Co., Riverside, N. J.
Scovill Mfg. Co., Waterbury, Conn.
Seymour Mfg. Co., Seymour, Conn.
Shenango Penn Mold Co., Dover, Ohio
Superior Bearing Bronze, Inc., Brooklyn
Titan Metal Mfg. Co., Bellefonte, Pa.
Universal Castings Corp., Chicago

MATERIALS & METHODS Engineering File Facts

NUMBER 112
April, 1946

MATERIALS: Plastics

Plastics — A Summary of ASTM Specifications

ASTM Spec. No.	Type	Grade	Flow Temp. Deg. F	Specific Gravity[8] At 77/77 F	Tensile Str.[7] Psi.-Min.	Heat Distortion Temp.[1] Min.	Impact Str.[2] Min.	Water Absorption[3] Max.	Remarks
D700-43T Phenolic Molding Compounds	1	—	250[4]	1.27	7000	—	0.36	0.15	Unfilled, transparent or translucent
	2	—	300[4]	1.45	7000	—	0.24	0.80	Wood-flour-filled, gen. purpose
	3	—	—	1.42	7000	—	0.34	0.80	Cellulose filled (wood-flour or cotton flock)
	4	—	—	1.45	5500	—	0.80	1.50	Cellulose filled (cotton rag[6]), moderate impact strength
	5	—	—	1.45	6000	—	1.75	1.75	Cellulose filled (cotton rag[6]), medium impact strength
	6	—	—	1.45	6000	—	4.00	1.75	Cellulose filled (cotton rag[6]), high impact strength
	7	—	—	2.00	5500	—	0.30	0.07	Mineral filled, high-frequency low-loss material
	8	—	—	2.00	5500	—	0.30	0.07	Mineral filled, very low-loss material
	9	—	—	1.95	4500	—	0.70	0.20	Mineral filled, general purpose
	10	—	—	1.95	5000	—	0.25	0.10	Mineral filled, heat-resistant
D701-44T Cellulose Nitrate (Pyroxylin) Sheets, Rods and Tubes	1	—	—	1.35-1.40		140	3.0		General purpose, transparent
	2	—	—	1.35-1.40	(See	120	4.0	(See	Improved toughness, transparent
	3	—	—	1.35-1.57	Note	140	1.0	Note	Pigmented, general purpose opaque (pigmented)
	4	—	—	1.35-1.57	9)	120	2.0	9)	Pigmented, improved toughness, opaque (pigmented)
D702-43T Cast Methacrylate Plastic Sheets, Rods, Tubes and Shapes	I	1[10]	—	1.18-1.20	5800	140-185	0.4	0.4	A general purpose material
		2[10]	—	—	—	—	—	—	
	II	1[10]	—	1.18-1.20	6500	185	0.4	0.4	Heat-resistant
		2[10]	—	—	—	—	—	—	
D703-44T Polystyrene Molding Compounds	1		—	1.05[11]	1.5[12]	169	0.30	—	General purpose material with or without pigments, colors or lubricants
	2		—	1.05-1.07	1.5[12]	169	0.30	—	Superior electrical-purpose material which may contain lubricants
	3	—	—	1.30-1.40	1.5[12]	183	0.25	—	General purpose, heat resisting material
D704-44T Melamine-Formaldehyde Molding Compounds	1	—	—	1.45-1.55	—	—	0.20	1.8	Alpha cellulose filled
	2	—	—	1.70-2.20	—	—	0.25	0.15	Mineral filled
	3	—	—	1.45-1.55	—	—	0.55	1.0	Cotton rag filled
	4	—	—	1.45-1.55	—	—	0.9	1.1	Melamine formaldehyde-phenol formaldehyde (85:15 ratio), chopped cotton rag filled
D705-43T Urea-Formaldehyde Molding Compounds		1	—	1.45-1.55	—	—	0.20	3.0	General purpose, alpha cellulose filled
		2	—	1.45-1.55	—	—	0.20	3.0	General purpose, having cellulose filler other than alpha cellulose
		3	—	1.45-1.55	—	—	0.20	3.0	Arc-resistant, cellulose filled material
D706-44T Cellulose Acetate Molding Compounds	I	1	314±9	1.34	5200	145	0.8	4.0	General purpose
		2	300±9	1.34	4300	130	1.0	3.5	
		3	286±9	1.34	3500	125	1.3	3.7	
		4	272±9	1.34	2900	115	1.7	4.0	
	II	5	356±9	1.34	6200	165	0.5	5.0	Heat-resistant
		6	332±9	1.34	5500	155	0.5	5.0	
		7	314±9	1.34	5000	145	0.8	4.7	
	III	8	300±9	1.32	4000	125	1.7	3.8	High impact strength
		9	286±9	1.32	3500	120	1.9	4.5	
		10	272±9	1.32	3000	110	2.2	5.5	
		11	260±9	1.32	2500	100	3.0	6.0	
	IV	12	332±9	1.34	5600	150	0.9	2.9	Moisture-resistant
		13	314±9	1.34	5000	140	1.1	2.7	
		14	300±9	1.34	4100	125	1.4	3.8	
		15	286±9	1.34	3300	115	2.0	3.2	

(Continued on page 1049)

ASTM Spec. No.	Type	Grade	Flow Temp. Deg. F	Specific Gravity[8] At 77/77 F	Tensile Str.[7] Psi.-Min.	Heat Distortion Temp.[1] Min.	Impact Str.[2] Min.	Water Absorption[3] Max.	Remarks
D707-44T Cellulose Acetate Butyrate Molding Compounds	I	1	300±9	1.21	3500	122	1.5	2.1	General purpose
		2	286±9	1.20	2700	114	1.8	2.1	
		3	300±9	1.22	4100	127	1.0	1.7	
		4	286±9	1.21	3600	119	1.2	1.8	
	II	5	332±9	1.23	5300	148	0.6	2.3	Heat-resistant
		6	314±9	1.22	4500	134	1.0	2.2	
	III	7	272±9	1.19	2000	109	2.3	2.1	High impact strength
		8	260±9	1.18	1400	103	3.1	2.1	
		9	272±9	1.22	3100	113	1.7	2.0	
		10	260±9	1.21	2500	105	2.5	2.4	
D708-44T Vinyl Chloride-Acetate Resin Plastic Sheets		1	—	1.32-1.36	8000	125	0.3	0.15	Transparent clear or colors only
		2	—	1.32-1.60	6500	135	0.35	0.15	Translucent or opaque colors only
		3	—	1.40-1.55	6000	130	0.5	0.15	Opaque colors only
D709-44T[14] Laminated Thermosetting Materials	I	X	—	—	9000	—	0.50[18]	3.3	Cellulose paper base for mechanical purposes
		P	—	—	6000	—	0.50[18]	2.8	Cellulose paper base, mechanical; punching stock
		XX	—	—	8000	—	0.40[18]	1.3	Cellulose paper base, electrical and mechanical
		XXP	—	—	6000	—	0.40[18]	1.3	Cellulose paper base, electrical and mechanical; punching stock
		XXX	—	—	6000	—	0.35[18]	0.85	Cellulose paper base, electrical and high humidity
		XXXP	—	—	5000	—	0.30[18]	0.85	Cellulose paper base, electrical and high humidity; punching stock
	II	C	—	—	7500	—	2.0[18]	2.5	Cellulose fabric base, mechanical
		CE	—	—	6500	—	1.3[18]	1.4	Cellulose fabric base, mechanical and electrical
		L	—	—	7000	—	1.2[18]	1.6	Cellulose fabric base, mechanical; fine machining
		LE	—	—	6500	—	1.0[18]	1.25	Cellulose fabric base, mechanical and electrical; fine machining
	III	A	—	—	5000	—	0.80[18]	0.95	Asbestos-paper base; heat-resistant
		AA	—	—	6000	—	2.50[18]	0.95	Asbestos-fabric base; mechanical and heat-resistant
D728-44T Vinyl Chloride-Acetate Resin Molding Compounds		1	—	1.30-1.35	7500	125	0.25	0.15	Transparent clear or colors only
		2	—	1.30-1.40	4500	125	0.35	0.15	Translucent or opaque colors only
		3	—	1.30-1.40	5000	130	0.35	0.15	Opaque colors only
D729-44T Vinylidene Chloride Molding Compounds		—	270-305	1.68-1.75	4000	150	0.5	0.1	(In the form of powder or pellets)
		—	—	—	—	—	—	—	
		—	—	—	—	—	—	—	
D742-44T Nonrigid Vinyl Chloride-Acetate Resin Plastics	I	1	—	1.24-1.29	3000	0[15]	—	0.30	Unfilled; plasticized with dioctyl phthalate or equivalent
		2	—	1.22-1.26	2600	−8[15]	—	0.40	
		3	—	—	—	—	—	—	
		4	—	1.19-1.24	1800	−18[15]	—	0.50	
		5	—	1.17-1.22	1400	−27[15]	—	0.60	
		6	—	1.15-1.19	1000	−36[15]	—	0.70	
	II	7	—	1.17-1.22	1400	−65[15]	—	0.60	Cold-resistant
		8	—	1.15-1.21	1400	−80[15]	—	1.00	
	III	9	—	1.41-1.45	1000	−20[15]	—	0.50	Filled; plasticized with dioctyl phthalate or equivalent and containing an inert filler
		10	—	1.36-1.40	1000	−20[15]	—	0.90	
D743-44T Nonrigid Ethyl Cellulose Plastics	I	1	—	1.14	1400	−13[15]	—	1.5	Molding type
		2	—	1.20	400	−4[15]	—	1.5	Molding type
		3	—	1.20	1800	−70[15]	—	2.8	Molding type
	II	4	—	1.14	600	−13[15]	—	1.7	Extrusion type
		5	—	1.20	200	5[15]	—	3.0	Extrusion type
		6	—	1.20	800	−40[15]	—	2.8	Extrusion type

(Continued on page 1051)

NUMBER 112 (Continued)

PLASTICS—A SUMMARY OF ASTM SPECIFICATIONS

ASTM Spec. No.	Type	Grade	Flow Temp. Deg. F	Specific Gravity[8] At 77/77 F	Tensile Str.[7] Psi.-Min.	Heat Distortion Temp.[1] Min.	Impact Str.[2] Min.	Water Absorption[3] Max.	Remarks
D744-44T Non-rigid Vinyl Chloride Plastics	I	1	—	1.22-1.38	2600	−4[15]	—	0.40	Unfilled; plasticized with dioctyl phthalate or equivalent
		2	—	1.21-1.34	2200	−13[15]	—	0.50	
		3	—	1.19-1.31	1800	−20[15]	—	0.65	
		4	—	1.18-1.30	1400	−27[15]	—	0.60	
	II	5	—	1.29-1.40	2200	28[15]	—	0.60	Heat- and flame-resistant
	III	6	—	1.21-1.39	2600	−50[15]	—	1.75	Cold-resistant
		7	—	1.19-1.38	2200	−60[15]	—	2.25	
	IV	8	—	1.39-1.52	1400	—	—	—	Filled
		9	—	1.49-1.65	1000	—	—	—	
D745-44T Non-rigid Vinyl Butyrate Plastics	I	1	—	(To be specified at a later date)					Thermoplastic type
		2	—	(To be specified at a later date)					
		3	—	1.05-1.50	1400	−40[15]	—	3.0	
		4	—	1.05-1.50	1000	−49[15]	—	3.0	
	II	5	—	1.05-1.50	1800	−31[15]	—	3.0	Curing (contains "cross-linking" agents causing transformation from thermoplastic to "thermoset" characteristics when properly cured) type
		6	—	1.05-1.50	1400	−40[15]	—	3.0	
		7	—	1.05-1.50	1000	−31[15]	—	3.0	
		8	—	1.05-1.30	1000	−67[15]	—	3.5	
D786-44T Cellulose Acetate Plastic Sheets	—	—	—	1.27-1.34	4000[16]	131	1.4[16]	4.5[16]	General type plastic sheets containing a maximum of 2.5% inert
	—	—	—	—	—	—	—	—	Pigment or filler
	—	—	—	—	—	—	—	—	
D787-44T Ethyl Cellulose Molding Compounds	I	1	310±10	1.14	—	140	2.5	1.8	General purpose
		2	290±10	1.15	—	130	3.5	1.8	
		3	270±10	1.15	—	125	3.5	1.7	
		4	250±10	1.16	—	115	3.0	1.7	
	II	5	310±10	1.14	—	135	5.0	1.8	Low-temperature resistant type
		6	290±10	1.12	—	120	5.0	1.8	
		7	270±10	1.09	—	115	5.0	1.8	
D788-44T Methacrylate Molding Compounds	I	—	311[5]	1.2	—	135-160	0.2	0.6	General purpose injection and extrusion molding compound
	II	—	347[5]	1.2	—	160-190	0.2	0.6	Heat-resistant, injection and extrusion molding compound
	III	—	311[5]	1.2	—	135-160	0.1	0.6	General purpose compression molding compound
	IV	—	347[5]	1.2	—	160-190	0.1	0.6	Heat-resistant, compression molding compound
D789-44T Nylon Injection Molding Compounds				1.15	9000	165	0.6	1.5	Powder for injection molding

Footnotes:

[1] In deg. F, at a fiber stress of 264 psi.

[2] Izod, in ft-lb. per in. of notch, at room temperature

[3] 24-hr. immersion, weight gain plus soluble matter loss in per cent

[4] Maximum continuous service temperature

[5] Maximum

[6] Or other suitable cellulose filler

[7] Generally determined with ⅛-in. specimen at room temperature

[8] Maximum unless a range is given

[9] Variation of properties with size of sample:

	Type 1				Type 2				Type 3				Type 4			
	0.003-0.029	0.030-0.059	0.060-0.125	Over 0.125	0.003-0.029	0.030-0.059	0.060-0.125	Over 0.125	0.003-0.029	0.030-0.059	0.060-0.125	Over 0.125	0.003-0.029	0.030-0.059	0.060-0.125	Over 0.125
Tens. Str., psi. (min.)	8000	7000	6000	5000	6000	5000	4000	3000	6500	5500	4500	3500	7000	6000	5000	4000
Water Absorption, % (max.)	3.5	3.0	2.5	2.0	4.0	3.5	3.0	2.5	3.5	3.0	2.5	2.0	4.0	3.5	3.0	2.5

[10] Both types may be furnished in either Grade 1 (having a highly polished surface) or Grade 2 (having a frosted, sanded, or otherwise unpolished surface)

[11] Minimum

[12] Deformation under load, per cent, maximum

[13] Edgewase, see ASTM standards for flatwise impact data

[14] Data for ⅛-in. sheet stock; data for other forms are presented in the ASTM specification (q.v.)

[15] Brittle temperature, maximum

[16] Data for 0.101-0.250 in. thick sheets; see below for data on thinner sheets (where such data varies from that for 0.101-0.250 in. sheets):

	0.005-0.030 in.	0.031-0.060 in.	0.061-0.100 in.
Tens. Str. psi. (min.)	5300	4700	4500
Water Absorption, %, (max.)	9.0	7.5	7.0

Compiled by Robert S. Burpo, Jr., Associate Editor

MATERIALS & METHODS Engineering File Facts

NUMBER 113
April, 1946

MATERIALS: Cast Iron
METHODS: Heat Testing

Heat Tinting Cast Iron for Microscopic Examination

Steps in Heat-Tinting Gray Cast Iron

1. Prepare the sample (cut to convenient size; clean to remove all dirt, oil and grease; and polish).
2. Immerse sample in 50% solution of ammonium hydroxide for a few seconds (this prevents the graphite from absorbing the etchant and exuding it later, which would stain the polished surface).
3. Etch sample with 2% phosphoric acid or 2% nital solution (a solution of nitric acid in ethyl, or methyl, alcohol).
4. Wash and dry.
5. Heat sample on hot plate (or in a bath of sand or molten metal) to approximately 575 F.
(For explanation of the resulting colors, see the table below.)

Heat-Tinting Gray Cast Iron

Color of Specimen to Unaided Eye	Microconstituent	Color of Microconstituent at Various Magnifications
First Perceptible Yellow	Steadite	x100, White x500, White matrix with dark dots
	Graphite	x100, Black, lustreless, with purple edges x500, Many blue dots along the edges
	Ferrite	x500, Brown with blue dots
	Pearlite[1]	x100, Brownish yellow x500, Ferrite is brown and cementite is white
Brown with Little or No Trace of Color	Steadite	x100, Pale gray x500, Grayish matrix with purple dots
	Graphite	x500, Red, purple and white along the edges
	Ferrite	x500, Brown to purple with blue dots
	Pearlite[2]	x100, Brown
Dark Brown Changing to Purple	Steadite	x100, The eutectic shows dark spots x500, Blue dots; the dendrites have purple edges
	Graphite	x500, More blue and less purple along edges
	Ferrite	x500, Similar to graphite
	Pearlite[3]	x500, Purple and brown, the lammellae cannot be distinguished
Purplish-Red with Blue Spots	Steadite	x100, Purple edges x500, Yellowish-red matrix
	Graphite	As above
	Ferrite	x500, Blue and white
	Pearlite[4]	x500, Red and purple
Blue and White	Steadite	x500, Red matrix with white dots
	Graphite	x500, White and blue edges (network structure appears at higher magnification)
	Ferrite	x500, White and blue
	Pearlite[5]	x500, Blue and purple

[1]Average color (at x100), brownish yellow
[2]Average color (at x100), brown
[3]Average color (at x100), brown with purple shades
[4]Average color (at x100), red and blue
[5]Average color (at x100), blue and white

Adapted from "Metal Treatment," Vol. 12, Winter 1945-46, p. 236.

engineering SHOP NOTES

Guide for Cutting Small Circles

Smooth, true cuts on circles or segments of small radius can be made easily with a hand-operated guiding device for the blowpipe. The figure shows such a device set up for operation. It can be easily fabricated from stock materials, and many shops will find it useful for doing work that usually requires larger, more elaborate equipment.

The device is made by fastening the nozzle supporting bar to the base of the guide by means of a capscrew and washer. Then the vertical member is bronze-welded to the top of the base 2½ in. from the end. The blowpipe hook is inserted through the hole in the block at the top of the vertical member and, when the blowpipe is properly positioned, is secured with an Allen setscrew.

View showing method of mounting circle cutting guide.

This guiding device is simple to operate. First, the center of the circle or segment to be cut is located on the plate and drilled to accommodate the pivot pin on the base of the guide. The plate is clamped or secured somewhat as shown in the figure. The pivot pin is inserted in the center hole and the blowpipe is positioned in the guide and carefully adjusted for the desired radius. The setscrew on the hook and the cap screw on the base are then tightened.

Once the cut is started, the operator needs only to move the assembly around the pivot, taking care to maintain the correct cutting speed. Smooth, accurate cuts can be easily made after a little practice with this device.

Practical Pointers on Alkali Cleaning

by Arthur P. Schulze

Whether the final finishing operation in your plant be electroplating, anodizing, electrotinning, black oxide finishing, painting, lacquering, enameling or japanning, proper surface preparation of metal is a factor of basic importance. In degreasing parts with alkaline solutions by the tank immersion method, cleaning efficiency depends to a great extent upon the design of the equipment.

Here are nine practical pointers in this connection that will prove particularly helpful to any plating superintendent or finishing foreman who contemplates installing a new alkali-cleaning tank in his plant or shop:

1. Plan on a tank of sufficient capacity to handle the volume of work required at highest production rate.
2. Construct a tank of welded steel and of sufficiently heavy gage. Do not use light gage metal or soldered joints.
3. Install sufficient heating coils or burners to bring the cleaning solution to the boiling point quickly.
4. Fit the coils on the near, or working side of tank. The surge created by the boiling of the solution at the coils will force floating oil across the tank to far side, keeping the working side comparatively free of oil.
5. See that the lowest heating coil is 3 in. from the bottom of the tank, and that the top coil is 3 in. below the usual solution level.
6. Provide for mechanical agitation of the solution by building a perforated shield over steam coil.
7. Provide an overflow dam, so that oil accumulating on solution surface will flow off.
8. Provide the main tank and overflow compartment with gate valves and crosses of sufficient size to permit rapid draining, and easy cleaning out of the tank. Install them at a point 3 to 4 in. from tank bottom, to avoid clogging of drains. After emptying the tank of solution, the muck can be removed with shovels.
9. A mesh grid or shallow basket placed on the bottom of the tank, and which can be raised at any time, is desirable. It makes easy the recovery of dropped parts.

Babbitting Without a Mandrel

by W. F. Schaphorst

When babbitting bearings it is best to use the shaft as a mandrel rather than a mandrel itself, pouring the molten babbitt directly around the shaft. Obviously, if the shaft is worn slightly it will be difficult to find a mandrel that will exactly match it. This method is best for a re-babbitting job. For new work, of course, a mandrel is satisfactory. However, the author has never had a failure when using the shaft itself as a mandrel.

One must pour the babbitt quickly. Take all the time desired for a painstaking job in preparing the molds so that they will receive all poured metal almost instantly. By pouring quickly, all sides of the shaft are heated simultaneously and expansion is the same all over.

Warping will occur when the metal is poured slowly and on one spot on the shaft. That spot becomes highly heated, expands and so springs the shaft that the hot spot will be on the convex side. Before the shaft springs back, the babbitt solidifies and holds the shaft in its bent condition.

In preparing the shaft for the mold, it is wise to burn some oily waste, creating an oily soot all around the shaft which provides the necessary clearance and serves as a good insulator against heat. If the soot isn't thick enough, wrap some thin tough paper around the shaft, pulling both ends together and making it perfectly smooth. Hence, this will provide a double insulator. Let the ends of the paper overlap ½ in. to 1 in. and paste the ends together, allowing time to dry before pouring. Or, instead of pasting, hold in place with a string, which will do double duty —also forming "oil grooves" in the finished bearing. Don't use paper too thick for it would make too much clearance.

All of this will make for a nice smooth babbitted job and but little, if any, scraping will be required.

The edges of the cast iron molds of a rubber goods manufacturer were continually breaking down due to frequent wire brushing. Replacing the edge with a silver soldered ring of steel was tried without success. Recently the manufacturer found the answer by building up the edges with 130X Monel welding electrodes.

—"Mechanical Topics," International Nickel Co.

Early Detection of Fatigue Cracks

By J. A. Bennett

In one phase of a study of fatigue damage being made at the National Bureau of Standards, it was necessary to have a method of detecting small fatigue cracks in the specimen without stopping the machine. Such a method was developed, based on the fact that the deflection of a rotating beam specimen under constant load increases when a crack forms. By making the measuring apparatus very sensitive, it was possible to stop the test when the crack area was about 12% of the original cross section.

One of a pair of contacts was fastened to the specimen end of a bearing housing on the R. R. Moore machine, the other contact being carried on a micrometer screw mounted on the bed of the machine. The contacts operated a signaling device through a tube circuit, so the position of the upper contact could be determined by raising the lower contact and noting the reading of the micrometer screw when the circuit was closed.

To get best results, it was necessary to mount the fatigue testing machine on springs to minimize vibrations from extraneous sources. Also, no specimen was used that caused excessive vibration when the machine was running. With these precautions it was possible to set the contacts 0.001- to 0.002-mm. apart, so that a deflection of this amount would operate the signal. The circuit can also stop the machine after a predetermined deflection.

Localized Heat for Soldering

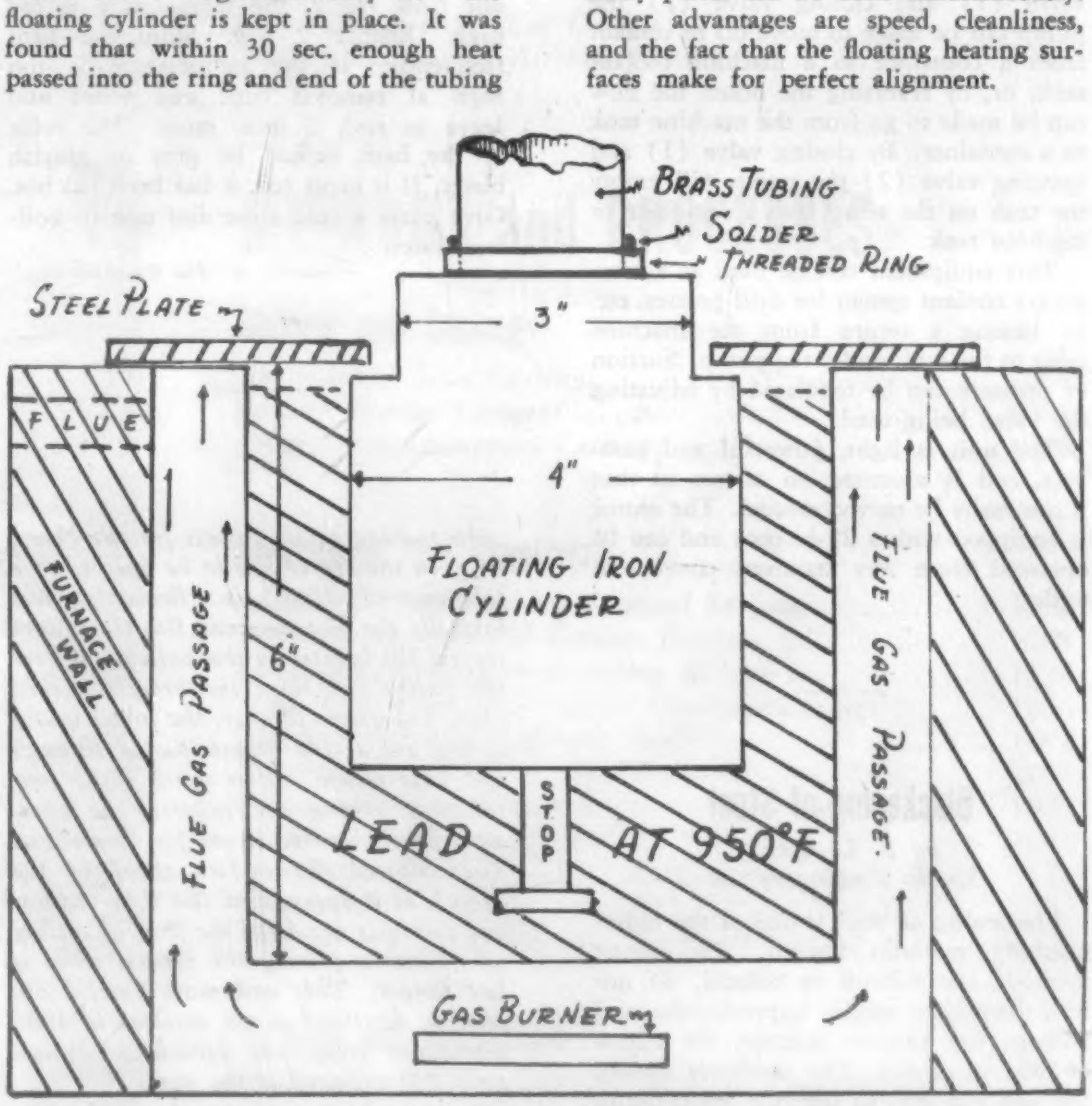
by Royal E. Hunt,
Brooklyn Union Gas Co.

In many soldering operations it is highly desirable to confine the heat to just the area being joined. One such instance was a job of soldering threaded rings onto the end of brass tubing without heating the tubing sufficiently to cause discoloration. To solve this problem, a method which involves conduction heating was devised.

The method consists essentially of floating cast iron cylinders in molten lead and then bringing the work to be soldered in contact with the hot iron cylinders. The sketch shows diagrammatically how the floating cylinder is kept in place. It was found that within 30 sec. enough heat passed into the ring and end of the tubing to melt the solder that had previously been placed in position.

Although the sketch shows only one iron float, ten of them were placed in one standard gas fired lead melting furnace; thus, ten pieces of work were soldered simultaneously in 30 sec. A machine is now being developed that will place the ten pieces of work in position, hold them there the required 30 sec., and then remove them finished.

Chief advantages of the new method are the low cost of equipment and that many pieces can be done simultaneously. Other advantages are speed, cleanliness, and the fact that the floating heating surfaces make for perfect alignment.



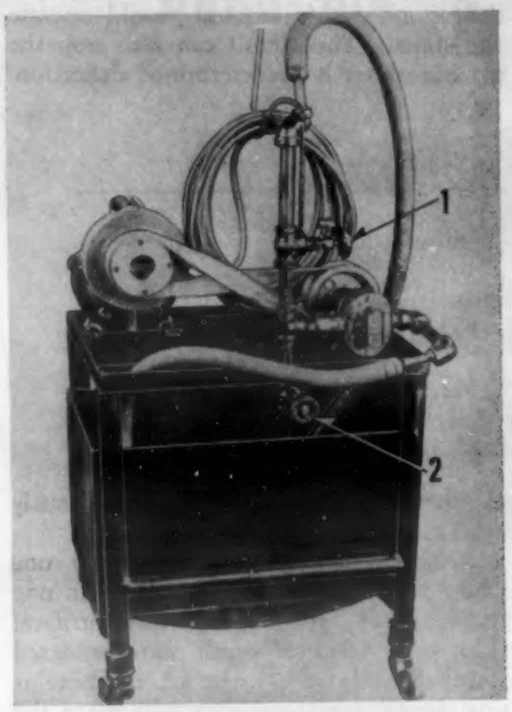
Schematic sketch of lead melting furnace showing the floating cylinder in place.

Portable Oil and Coolant Pump

by H. Small,
Westinghouse Electric Corp.

The accompanying illustration shows a motorized pump and tank that has proved to be useful in departmental or general maintenance for servicing machines that use oils and coolants.

The variations in the application of this setup are made possible because of the three-way piping system. By opening valve (1) and closing valve (2) the pump can be made to move oil or coolant from a container to a machine coolant tank; or, by reversing the hoses, the flow can be made to go from the machine tank to a container. By closing valve (1) and opening valve (2) the pump will empty the tank on the setup into a container or machine tank.



This handy pump and tank has many useful applications around the shop.

This equipment can be used as a temporary coolant system for drill presses, etc. by having a return from the machine table to the tank under the pump. Suction or pressure can be regulated by adjusting the valve being used.

The unit is light, powerful and compact, and is mounted on castors so that it can easily be moved around. The motor is equipped with a 25-ft. cord and can be operated from any standard convenient outlet.

Blackening of Steel

by F. L. Atkin,
Sparks-Withington Co.

Blackening of steel is one of the oldest finishing methods known. Too many methods are difficult to control, do not lend themselves readily to production, and perhaps the process destroys the effects of heat treatment. The tendency during the late war was to use low temperature oxide baths.

Needless to say, in oxide bath processing the work must be free of oil, grease, oxide, scale or rust. There are four chief methods of cleaning: alkali soak, electrolytic method, combination of these two, or vapor degreasing. Of these four, the alkali soak is the most economical and should be operated at 200 F and circulated by pump or air, or perhaps by boiling.

Vapor degreasers are satisfactory where the work has lock seams, blind holes and other recessed areas. Some alkali cleaners leave a film trace, best removed by an acid dip, consisting of 2 qt. of nitric acid, added to 40 gal. of mixture of equal parts of water and muriatic acid. A cold water rinse follows.

We have tried several blackeners in our laboratories but continue to use in production Houghto-Black. Low carbon steels blacken in 10 min.; carburized steel in 15 min.; nickel and chromium steel, in 15 to 20 min.; high chromium steels do not oxidize at all.

Carburized steels sometimes acquire a red or green film, which will not rinse off. This can be prevented by soaking the parts after cleaning for 5 to 10 min. in a hot solution of 5 to 10 lb. of sodium cyanide in 100 gal. of water. The blackening bath forms a sludge which should be removed once a month.

The solution must boil to blacken properly, the agitation assisting the process. The Houghto-Black No. 15 is used 10 lb. per gal. of water, permitting an operating temperature of 290 to 295 F. If the work does not show a deep color, raise the temperature—2 deg. may suffice. If the work is red, green, gummy, or does not rinse freely, the temperature is too high. Reduce 2 deg. Skim the bath frequently. If the temperature is too high at removal time add water and leave in tank 2 min. more. The color of the bath should be grey or greyish black. If it turns red, it has been too hot. Give parts a cold rinse and one in boiling water.

—*Courtesy of "The Houghton Line"*

In making small pulleys for the Navy, holes in the center had to be finished to a tolerance of 0.0005 in. Broaching was logically the best method. But there were several thicknesses to the pulleys. Where the pulley was thick the broach worked okay, but where thinner, the metal would spring out as the broach passed through and later return. After much futile consultation among the experts, the operators finally worked it out for themselves. They slowed the surface speed of the broach as it approached the thin sections and carefully regulated the flow of cutting oil. Chrome plating the broach made it last longer. This and more careful operation, described above, resulted in 4000 operations from one broach as against only 200 expected at the start.

—John J. Hoenigman, Jr.,
Union Special Machine Co.

Hand-Bending Tool for Small Tubing

By Carroll E. Adreon,
Glenn L. Martin Co.

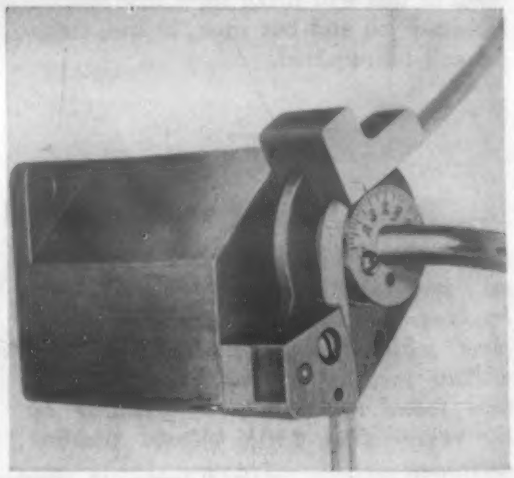
A new hand-bending tool, which permits all kinds of small tubing to be curved to any desired angle, has been developed at the Glenn L. Martin Co., Baltimore. It consists of a sturdy steel base, which may be used in a vise or clamped onto a bench; a revolving radius rod equipped with a handle for turning; a stop block grooved to hold the tubing; and a movable radius block, which guides the tubing around a bend roll centered on top the base.

This roll, cylindrical in shape and also grooved, has a top plate scribed in 360 deg. A measuring point is marked on the movable radius block. The radius and holding blocks and the roll are so grooved as to prevent crushing or change in section of the tubing.

In operation, the tubing is inserted in the groove of the stop block and the movable block which has been returned to the zero degree point. The movable block is then pulled around the bend roll, being connected to the revolving radius rod, until the measuring point is directly opposite the mark of the angle desired.

Allowances can be made for tubing having a "spring back" characteristic by merely moving the measuring point to as many degrees beyond the desired angle marking as the tube will spring back when released. An operator can easily measure this amount of allowance needed from the spring back shown on the top plate of the bend roll, when pressure on the handle is released. Utilizing the same principle, tools may be made for bending tubing of any size.

By the simple substitution of a set of phenol fibre blocks, similar in design to the metal blocks, hot-dipped or tinned spiral high-electrical cables (for example, battery cables) also can be bent in the new tool. Use of the phenol fibre accessories prevent the semi-molten coating on the wire from adhering to the blocks, as would be the case with use of the steel blocks on the original tool.



The tube bending tool with a piece of tubing in place being bended.

Chief advantages of the new device lies in the great amount of time saved as compared to ordinary hand bending operations, the extreme accuracy to which the tubing can be turned and a material saving in that there is no scrap.

MATERIALS & METHODS DIGEST

A selection of outstanding articles on engineering materials and processing methods in the metal-working industries.

MATERIALS and DESIGN

Metals and Alloys

Nonmetallic Materials

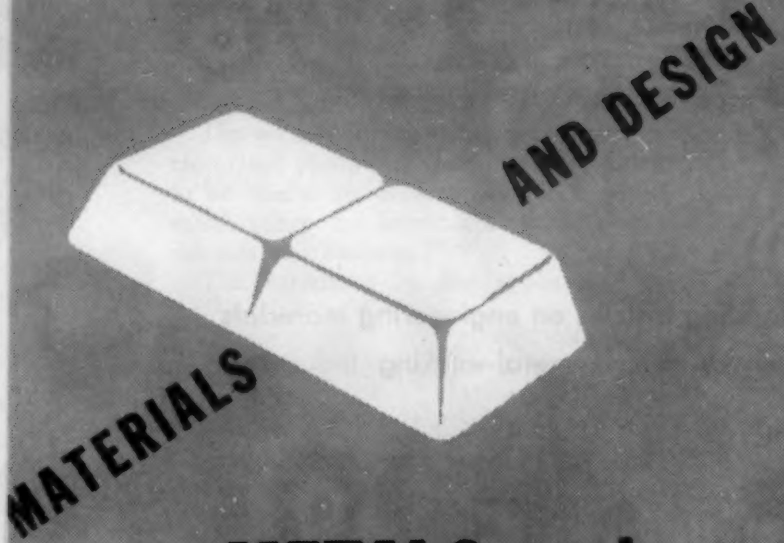
General Product Design

METHODS and PROCESSES

Melting and Casting

Fabrication and Treatment

Testing and Inspection



METALS and ALLOYS

Engineering properties and applications of carbon, alloy and stainless steels, irons and nonferrous metals and alloys. Selection and evaluation of metallic materials for engineering service. New alloys and modifications.

Some Properties of Titanium Steels

Condensed from "The Journal of The American Ceramic Society"

Although titanium has become well known as a carbide stabilizer in stainless steel, it is only recently that the advantages of using it for a similar stabilizing purpose in ordinary low-carbon steels have been realized. This has come about because of the discovery that steel or iron of high purity, with all of the carbon combined with titanium, can be given a satisfactory smooth white vitreous enamel coating (without blisters or black specks) without the use of a ground coat, simply by fusing any good white enamel to it.

The saving in enameling costs and the prevention of rejections justifies the extra cost of titanium steel. The titanium content must be more than 4.5 times the carbon content. This steel has been made commercially by the basic open-hearth process, and the requirements for successful manufacture include suitable precautions to prevent oxidation of the titanium.

Structurally, this steel consists exclusively of ferrite and titanium carbide, which occurs as fine angular crystals scattered indiscriminately through the ferrite grains. The ferrite, however, holds practically no carbon in solution. The steel is of excellent quality for deep-drawing and does not have a definite yield point even when normalized or annealed so that stretcher strains cannot occur in it. It is not subject to strain aging of any kind, and is resistant to caustic embrittlement and to attack by hydrogen at high temperatures and pressures. It also resists sagging at enameling temperatures better than regular enameling steel or iron.

The yield strength of titanium steels is low, and, consequently, their use would be restricted to applications where strength is relatively unimportant, such as household enameled ware. However, higher strength titanium steels containing manganese, nickel and copper are in the development stage and have shown excellent ductility and toughness, fair weldability, good resistance to strain-aging embrittlement, and better resistance to grain growth at high temperature than the regular titanium enameling steel.

Vitreous enameling tests of the various alloyed titanium steels confirmed the expectation that as long as sufficient titanium is present to stabilize all of the carbon effectively, the presence of other alloying elements does not interfere with the single coat, blister-free enamel application. The adherence of the enamel to the steel, however, was somewhat variable in these alloy compositions.

Higher strength titanium alloy steel can be made by adopting the following specification: carbon, 0.08 (max.); titanium, 5 times carbon (min.); manganese, 1.3 to 1.6; and silicon, copper, nickel and molybdenum, each 0.4 to 0.6% (the molybdenum content is optional). Steel of this sort can be made by the basic open-hearth process, and the processing of the steel should offer no difficulty.

—G. F. Comstock. *J. Am. Ceramic Soc.*, Vol. 29, Jan. 1, 1946, pp. 1-7.

Surface Preparations for Magnesium Alloys

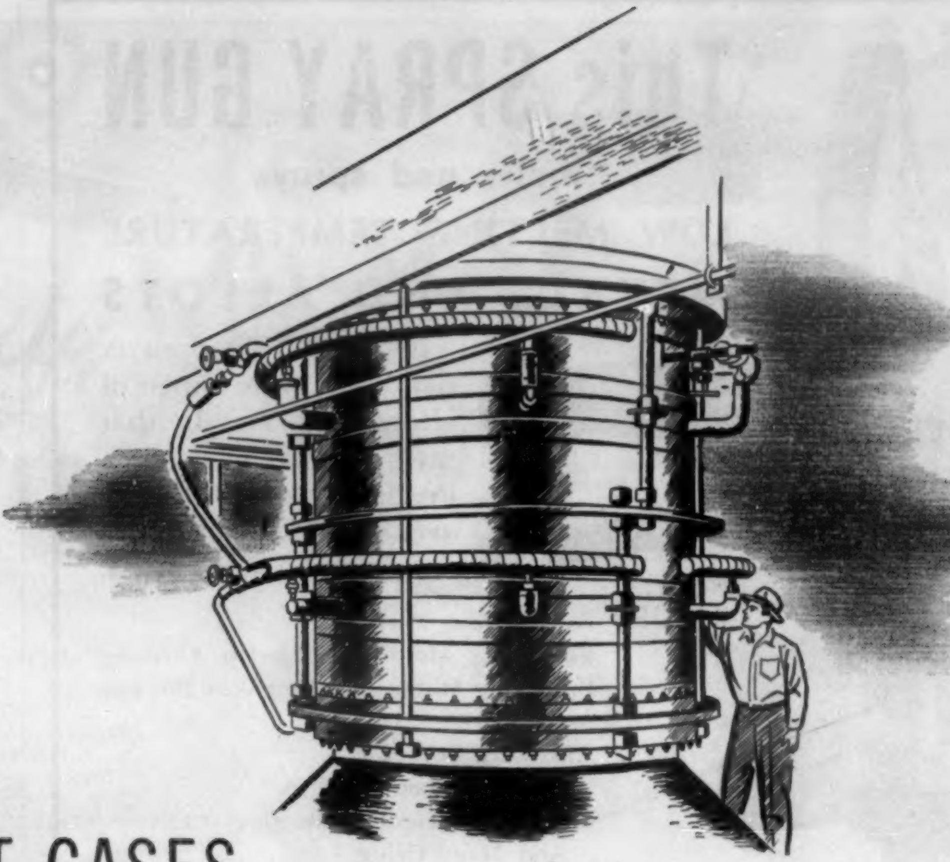
Condensed from "The Journal of the Institute of Metals"

It had been suspected that differences of results in corrosion tests of magnesium base alloys were due to difference of surface preparation before exposure to 3% sodium chloride solution. Thus, the matter was studied further. Eighteen cylindrical specimens of magnesium-base aluminum-containing alloy were machined to form. The specimens consisted of three groups of six each.

Three specimens from each group were prepared on #1 F emery paper, the remaining specimens having been prepared on #1 F paper, followed by 00 emery paper and moist pumice powder. The specimens were all degreased in carbon tetrachloride vapor, and those prepared with pumice were then immersed in the 3% sodium chloride solution.

The three sets of specimens prepared only on #1 F paper were immersed in beakers of freshly made salt solution to which magnesia had been added. Experiments indicated that specimens prepared on #1 F emery paper were inherently less resistant to salt water attack than those finished with pumice; further, that specimens of low iron content, prepared with pumice, were superior to similarly prepared specimens of normal iron content. Further experiments and tests were conducted along these lines.

It was decided that the three new methods of surface preparation do not cause appreciable differences in the general form of the corrosion curves. However, specimens of low iron content corrode more slowly with a surface preparation other than that finished with #1 F emery. Chemical and X-ray examination showed that the



RESISTS HOT GASES

Stainless steel unit operates at 1000° F.

Corrosive gases carrying pulverized catalyst rush through this huge expansion joint at more than 1000° Fahrenheit. For this severe service, design engineers looked for a metal that was strong and tough and had good resistance to heat, wear, and corrosion. They chose stainless steel. For stainless steel has a unique combination of properties which make it the one best metal for thousands of industrial and consumer uses, ranging all the way from food and chemical-processing equipment to streamlined trains and store fronts.

If you would like to keep informed of the newer uses of stainless and other alloy steels, ask to receive the monthly publication ELECTROMET REVIEW. Or, if you need advice on their production, properties, or fabrication, write our Technical Service Department. While we do not make steel—but manufacture the ferro-alloys used in its production—we have, through years of research and engineering, acquired a fund of information on the production, properties, and uses of alloy steels and irons.

ELECTRO METALLURGICAL COMPANY
Unit of Union Carbide and Carbon Corporation
UCC
30 East 42nd Street, New York 17, N. Y.

In Canada: Electro Metallurgical Company of Canada, Limited, Welland, Ontario

STAINLESS STEEL

BEAUTIFUL ENDURING STRONG TOUGH

BEST COMBINATION OF THESE QUALITIES

abrasive on the #1 F emery paper consists mostly of alumina, but also 7% of iron in the form of Fe_2O_3.

It may be that the use of this paper has resulted in some contamination of the metal surface by the iron and led to approximately similar corrosion rates for material of both low and normal iron content. The author has noted that oxides and hydroxides of iron when in contact with a magnesium alloy surface cause a marked diminution of the resistance of the alloy to salt water attack.

Not only pumice but glass-paper and polished finishes were studied, they being free of iron; with such treatment corrosion resistance of the alloys was better. It has not been possible to prove directly that iron pick-up occurs when specimens are prepared with emery.

The practice of preparing specimens with emery paper is a standard procedure. There should be further tests, prepared in ways already described, but which have also been annealed at low temperatures for stress relief. Similarly, tests on pickled and electrolytically polished specimens will be desirable.

—F. A. Fox & C. J. Bushrod, *J. Inst. Metals*, Vol. 72, Jan. 1946, pp. 51-63.

Scaling of Cobalt-Base Hard-Facing Alloys

Condensed from "Stahl und Eisen"

A series of cobalt-bearing hard-facing alloys have been used for both the seats of exhaust valves and the valves themselves in internal combustion engines because of their resistance to corrosion, scaling and erosion at high temperatures. The alloys used in the series of experiments have the following composition ranges: 1.1 to 1.5 carbon, 1.0 to 2.5 silicon, 0.2 to 0.4 manganese, 60 to 65 cobalt, 25 to 28 chromium, and 3 to 8% tungsten.

The effect of varying cobalt content on the scaling and erosion properties in the presence of the combustion of lead-containing fuels was investigated, and the results of these tests (at scaling temperatures, 1650 to 2000 F) show that: (1) the hard-facing alloys containing 1 to 36% cobalt exhibit about the same resistance to scaling in air as do similar materials containing 60 to 65% cobalt; (2) alloys containing 30 to 36% cobalt are about as resistant to scaling caused by the combustion of lead-free fuels as the alloys containing 60% cobalt; and (3) in the presence of the products of combustion of high lead content fuel, the relation of cobalt content to amount of scaling or erosion is about the same as when lead-free fuel is burned, except that the scaling is more pronounced in the case of the high octane gasoline.

From these tests it seems that the cobalt content alone does not determine the scaling resistance; the effect of carbon content has been found to be quite important. In tests involving steels having carbon contents of 0.19 to 1.39%, it is shown that the scaling resistance of 30% chromium steels decreases with a corresponding increase in the carbon content.

(Continued on page 1070)

Specify MO-MAX for
SUPERIOR PERFORMANCE
YOU CAN expect better results from tools made of this pioneer molybdenum-tungsten high speed steel. MO-MAX has clearly demonstrated its superior qualities in drills, reamers, lathe tools, cut-off tools, tool bits, milling cutters, hobs, circular saws, thread rolling dies, counterbores, broaches, lathe centers, spot facers, circular and flat forming tools, dies for both hot and cold work, taps, thread chasers, etc.
MO-MAX

Contributing factors to the scaling and erosion resistance of these types of materials have been found to be variation in the tungsten content, and the presence of ferrite and austenite in the valve or valve seat material.

—H. Cornelius. *Stahl u. Eisen*, Vol. 33, Aug. 17, 1944, pp. 529-532.

Strength and Forming Characteristics of Aluminum-Alloy Sheet

Condensed from "Transactions" of the American Society of Mechanical Engineers

This is a study of strength characteristics and forming limits of various aluminum alloy sheets when subjected to hydraulic pressure over a circular area at temperatures up to 500 F. The strain distributions were analyzed with a photogrid after the bulges failed. The bulges showed a balanced biaxial strain state over most of the contour except for a very narrow range of local deformation near the fractures.

The maximum meridional strain outside the necked area at the pole of the bulge generally exceeded the uniform elongation known from tensile tests. The forming limits for all annealed conditions increased considerably with increasing temperature if the temperature exceeded a certain critical value, 250 to 400 F, depending on the alloy.

The heat-treated conditions of 24S and 61S were only slightly affected by the testing temperature, while the forming limits (uniform stretch) of 75S-T, R301W and R301T were materially increased at elevated temperatures. Reduction of thickness (measure of ductility) followed the same trend as the forming limit.

Twenty-one different conditions of seven aluminum alloys (3S, 52S, 61S, 24S, 75S, R301 and R303) were tested. The first three were as bare sheets, while the next two were only as clad sheets, while 24S was tested in both the bare and clad form. Equipment consisted of a bulging head and a hot oil displacement cylinder capable of furnishing oil under pressure up to 3000 psi. to the head on which the specimen was clamped.

Bulging pressure was recorded by a helical-type 3000 psi. recording pressure gage tapped into the oil line connecting the bulging head and displacement cylinder. A synchronous-motor drive for the recording chart permitted the recording of a pressure time (stroke) curve for any desired test. Elevated temperatures were secured by induction heaters. While most of the blanks failed by splitting close to the crown in the longitudinal direction, the final appearance of a bulge was determined by the ductility of the alloy.

The pressure required to burst such a sheet is a function of the tensile strength of the metal and the thickness and curvature of the part at the moment of failure. As to the effect of increasing temperature, bursting pressure followed the same trend as tensile strength, according to a previous investigation. On the contrary, the relation between different alloys is clearly different in the bursting test than in the tensile test.

Of the artificially aged alloys of very

CMP
PRECISION
THINSTEEL
Here, the true American
industrial scene. The pioneers'
new principles in equipment
first provided the combina-
tion which revolutionized
metal rolling science.
thinsteel facts
COILS UP TO 300 LBS. PER INCH OF WIDTH
EXTREMELY CLOSE TOLERANCES
WIDE RANGE OF PHYSICALS
GAUGES THIN AS .001 INCH
WIDTH UP TO 24 INCHES
CARBON AND ALLOY GRADES
CMP
PRECISION COLD ROLLED
STRIP STEEL
GIVES MAXIMUM PRODUCTION PER TON
THE COLD METAL PRODUCTS CO.
YOUNGSTOWN, OHIO
Sales Offices: NEW YORK • CHICAGO • DETROIT • ST. LOUIS • BUFFALO • DAYTON • LOS ANGELES

high strength, only 75S-T exceeded 24S-T in bursting strength at room temperature, while 24S-RT, 24S-T81, 24S-T86 and R301-T exhibited a lower bursting strength than 24S-T.

—G. Sachs, G. Espey & C. B. Kasik, *Trans. Am. Soc. Mech. Engrs.*, Vol. 68, Feb. 1946, pp. 161-171.

Aluminum Alloy for Bearings

Condensed from "Light Metals"

Prior to 1939, Switzerland and other countries began the development of bearing alloys based on aluminum, with three compositions introduced: No. 11, with small quantities of magnesium and zinc; No. 21, which is the eutectic aluminum-silicon alloy, with additions of copper, nickel, manganese and magnesium (copper and nickel totaling 6%); and No. 31, with 8% tin, plus copper, nickel and a little magnesium.

Nos. 11 and 31, medium-hard alloys, have good running qualities and good resistance to edge pressure. No. 31 is preferred to No. 11 when it is impossible to give the bearing surface a high finish and when it is not expedient to run the bearing in gradually under load.

The aluminum-base alloys can withstand very high loads, equal to the two best lead-tin bronzes. They possess better running-in qualities than any of the bronzes or cast irons examined, though it is admitted that tin-base bearing metals remain unsurpassed. Rapid increase in load and careless running-in are sustained better by the aluminum alloys than by bronzes, due to the better cold-working properties of the light metal compositions, their high capacity for oil adsorption and good heat conductivity.

In tests of dry friction against the rough, hardened surface of a steel shaft, the aluminum was at least as good as the best bronzes. The aluminum was superior to bushings with tin-base metal linings, with no trouble from undue heating up—and with oil lubrication absent.

The aluminum bearings have been found excellent for main bearings and connecting rods in automobiles, having high heat conductivity and a minimum of seizure. The No. 31 has been found best among all metals as bearings for steam turbines. They are suitable for bearings with very little clearance, having been used for the main spindle of lathes.

The No. 11 is high in corrosion resistance, exhibits good adsorption of an oil film, and is low in first cost. The No. 21 is suitable for vibratory loads, has a thermal expansivity similar to bronze, runs with minimum lubrication, and does well heated up. The No. 31 is readily movable, easily run in and resistant to edge pressure, and shows no undue tendency to seize, even with minimum lubrication.

These aluminum-base bearings are not to be considered as substitutes in the commonly accepted sense of the word, for they have permitted development of new and improved designs. They have high loading capacity, are relatively insensitive to load variation, are readily run in, have high heat conductivity, are light in weight, are readily machined, wear well, and are not affected by heat developed in running.

—*Light Metals*, Vol. 8, Dec. 1945, pp. 579-591.

American vs. European Magnesium Castings

Condensed from "American Foundryman"

The three most widely used European alloys are AZG, A-8 and AZ-91. In the U.S.A., binary magnesium-aluminum alloys were initially used, but in recent years the American casting industry has been developed largely around two alloys, ASTM-4 and ASTM-17, the former being similar to the European AZG. ASTM-4 has been by far the most popular casting alloy in the United States. The second most popular, ASTM-17, is not much used in Europe except experimentally.

There are four different compositions representing the chief casting alloys of the United States and Europe, with compositions as follows:

	Aluminum	Zinc	Manganese
AZ-91	9.6	0.4	0.2
A-8	8.0	0.4	0.2
AZG or ASTM-4	6.0	3.0	0.2
ASTM-17	9.0	2.0	0.2

The Battelle Memorial Institute tested these four along eleven lines: Tensile properties of separately cast bars, tensile and Charpy impact properties at room temperature and minus 75 F, fatigue limit, susceptibility to hot shortness or hot cracking, susceptibility to microporosity, corrosion and effect of iron content, amenability to heat treatment, solidification range, leak tightness, amenability to degassing, and to grain refining operations.

The mechanical properties of A-8 and ASTM-4 are comparable, as are AZ-91 and ASTM-17. The last is slightly superior in the heat-treated and aged condition. As to corrosion resistance, ASTM-17 is slightly inferior to the other three because of lower manganese. ASTM-4 is slightly more susceptible to hot shortness than the other three. This alloy is also markedly more susceptible to microporosity than either ASTM-17 or AZ-91. A-8 is slightly more susceptible to microporosity than ASTM-17 or AZ-91, but much superior to ASTM-4.

ASTM-4 castings are much more liable to leak than castings of the other three materials. There is no substantial difference among the four in amenability to degassing or grain-refining treatment. The minimum burning temperature of A-8 and AZ-91 is 800 F, which is above the normal solution heat-treating temperature.

ASTM-4 will burn rapidly if heated above 650 F, which is about 80 F below the normal heat-treating temperature. ASTM-17 will burn if rapidly heated to above 740 F, which is 30 F below the normal heat-treating temperature.

In general, only slight advantages of the two high zinc alloys, ASTM-4 and ASTM-17, over the two low-zinc alloys could be found, but they are subject to very serious disadvantages. It is believed, therefore, that they will be eventually abandoned in the United States, just as they are fading out in Europe.

—L. W. Eastwood, J. A. Davis & James DeHaven. *Am. Foundryman*, Vol. 8, Dec. 1945, pp. 54-68.

MATERIALS AND DESIGN

NONMETALLIC MATERIALS

Design-uses of plastics, plywood, fibre, glass, rubber, ceramics, etc. as engineering materials. Composite metal-nonmetal combinations. New types and forms of nonmetallic materials.

Wood vs. Metal Construction in Aircraft

Condensed from "S.A.E. Journal"

Designing and developing their AT 10 plywood covered airplane for the AAF, which was built in substantial quantities and on production lines side by side with all-metal construction, gave the Beech Aircraft Corp. an opportunity to gage the merits of all-metal aircraft construction versus the wood type of airplane fabrication. Because of the wide variation of the properties of the wood and the manner in which the load was applied to the wood member, it was found impractical to use a design similar to that used in all-metal construction.

Experiment established the following principles:

Wing Surfaces—1. For convenience in fabrication and for the purpose of servicing and maintenance, the outer removable panels are attached to a center-section structure.

2. All spanwise bending is carried by a main spar located at the approximate maximum depth of wing contour.

3. All torsion and drag sheer forces to be carried through skin covering only.

4. Rear spar to carry shear and tension or compression loads only.

5. Eliminate spanwise stringers and space ribs close enough together so the plywood covering has sufficient support.

Tail surfaces—1. Where the structure is discontinuous, follow procedure used in wing structure.

2. When the tail surface is continuous, sparwise stringers may be used provided torsional stresses in skin covering and stringers are low.

3. Where the surfaces are discontinuous and attached to the fuselage, the bending loads must be transmitted with a type of attachment which makes the problem of load determination in the attachment reasonably possible.

The fuselage structure must be designed with specific members capable of carrying the entire bending loads as axial loads in these principal members. The skin is used only to transmit shear loads and to hold the assembly together.

Experience has shown that the best protection of the external surfaces of the plywood was given by applying several coats of a wood sealer, doping down to this surface a light weight airplane fabric finished in the typical fabric covered airplane system. Plaskon No. 250-2 was found to be the most usable and practical of the ureaformaldehyde glues investigated.

One of the principal limitations in wood aircraft construction is size. As size increases, construction of wood becomes more impractical as there are substantial possible savings in the weight of the structure when fabricated of metal. Even in the smaller size of airplanes the weight of the metal structure is more favorable than that of wood, although the apparent percentage advantage is reduced.

When only a few airplanes are to be built, the cost of tooling is less for wood than for metal. Also, wood construction lends facility for rapid and inexpensive alteration, if changes of design are required. In large quantities, the cost of fabrication of wood versus metal construction has a somewhat different aspect.

Experience at Beech led to the conclusion that when an airplane is designed for production there is little if any advantage of wood over metal construction, indications being that for practical purposes both will be the same. The finishing and protective coating add extra weight and expense to the wood airplane. Metal structures require no external paint finish.

—Herb Rawdon. *S.A.E. Journal*, Vol. 53, Dec. 1945, pp. 691-712, 718.

Plastic Compasses

Condensed from "Machine Design"

Because of its sturdiness, small size and dependability, a magnetic compass was selected as a standard vehicular instrument for use in Army tanks. Except for a few small metallic parts, this compass was made entirely of thermoplastic materials.

The overall dimensions of the compass were 3 by 5 in. and its weight was 15 oz. The case and top and bottom caps were made of cellulose acetate butyrate, as were many of the internal parts. The compass

bowl was made of methyl methacrylate (transparent) plastic. In all, there were 17 plastic parts in this instrument, and they were produced by injection molding from multiple-cavity molds.

The assembly methods included cementing some of the parts and having studs and bosses molded into others so that they could be joined by heading over the stud with a hot iron.

To insure reliability, each compass was exposed for 2 hr. to temperatures of −58 F and 158 F. In addition, each compass unit was subjected to a pressure test of 9 in. of mercury (absolute—about 19 psi.). Vibration tests at 500 to 2500 cycles per min. (with an amplitude of 0.020 in.) were given each instrument.

These vehicular compasses were the result of the cooperative efforts of various Army agencies, several instrument makers and the Dept. of Terrestrial Magnetism at the Carnegie Institution of Washington, D. C.

—D. J. Faustman. *Machine Design*, Vol. 18, Jan. 1946, pp. 133-134, 182.

Rubber Molds Facilitate Casting of Plastics

Condensed from "Mill and Factory"

Developed by William Lockwood, chemist for Duorite Plastic Industries of Culver City, Calif., synthetic rubber molds are being used by West Coast plastics fabricators for casting small plastic objects with speed and efficiency.

The rubber is a thermoplastic material with a melting point that is considerably higher than melting points for the more common thermoplastic casting resins. Therefore, it can be reclaimed innumerable times by melting and used in connection with many types of plastics.

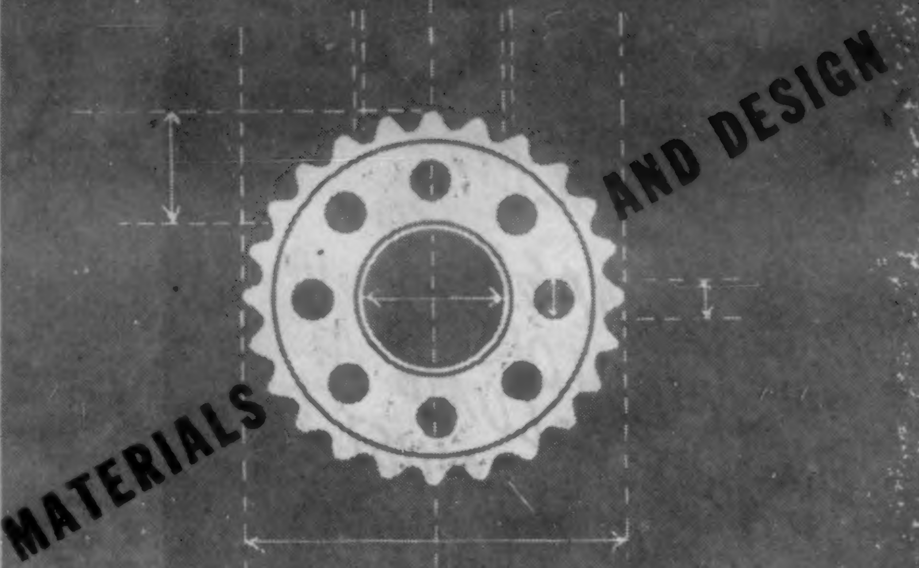
Molds are made simply by melting the rubber in a double boiler, and pouring the molten material over a model of the object that is to be cast. The rubber molds can be made on models that have slight undercuts or projections, because they are flexible enough to be stretched in the process of removing the models or subsequent plastic casts.

Casting is done by pouring a resin into the mold, and curing by heating or cooling in conformity with the nature of the resin. Rubber molds would naturally be unsuitable for casting large or bulky objects, since the stresses caused by the presence of large quantities of resins would quickly cause distortion of the mold surfaces. However, the opposite is true when it becomes necessary to cast small objects.

The molds will retain critical dimensions with almost minute accuracy, in spite of rough treatment, such as dropping on the floor, and when the castings have been properly cured they can be removed simply by stretching the mold a bit.

Prior to the development of the rubber molds, plaster was almost universally used in making small plastic molds. Such molds were very easy to break and difficult to salvage.

—T. A. Dickinson. *Mill & Factory*, Vol. 38, Jan. 1946, p. 105.



GENERAL PRODUCT DESIGN

Selection, applications and design of parts made by various fabricating methods or made of special materials. Properties and uses of finishes and coatings. Design and materials for specific products or fields. General engineering design trends or principles.

Railroad Passenger Car Design

Condensed from "Railway Age"

A paper read by Allen W. Clark, assistant general mechanical engineer, American Car & Foundry Co., at a session of the Railway Division of the American Society of Mechanical Engineers, brought out the following points:

Streamlined trains in 1946 will have the dimensions adopted in 1940. Some will have the A.A.R. skirts but others will appear without any or with higher ones. Owing to damage under unusual wreck conditions, some railroads will require weight increases of 5000 or more lb. per car.

Materials which will continue in use are: (1) mild carbon steel, copper bearing, (2) low-alloy high-tensile steels, (3) stainless steels, and (4) aluminum alloys. New alloys with improved properties are now available also. As the total weight of the material in the structural shell is only from 25 to 35% of the total weight of the car, the percentage that can be saved by the use of light high-strength materials and careful design is limited.

Of the four basic materials, mild carbon steel will produce the heaviest car, other factors being equal. Lowest costs favor the use of mild carbon steel. The cost of aluminum has been reduced and when minimum weight is vital, aluminum alloys will be preferred.

In exterior appearance the 1946 model will be either shiny (unpainted), painted, or a combination of the two. The surface of stainless steel is not well adapted to application of paint. Low alloy high-tensile steel and aluminum construction are best adapted.

In the luxury cars there will be decorative features and new facilities. The coaches will be less radical but more comfortable. The wide diversity of plans adds to cost and hampers production. There could be more standardization without the danger of stifling progress.

Speaking as an authority on passenger traffic, H. F. McCarthy, executive assistant to the President, New York, New Haven & Hartford Railroad, questioned Mr. Clark's statement that the cost of low-alloy, high-tensile steel construction is less than for stainless steel with little difference in weight. If this is so, he said, stainless steel will not be used except for trim, since the passenger salesman can sell a comfortable seat but not a center sill. Mr. McCarthy advocated not luxury items, but an easier ride, truck research and design, weight saving, greater cleanliness, seat spacing, air-conditioning, better lighting and the elimination of noise.

P. W. Kieffer, chief engineer, motive power and rolling stock, New York Central, said that in his belief the next most important problem is to reduce the effects of lateral car action to the same relative standards as that of the vertical.

Discussing materials, Col. E. J. W. Ragsdale, chief engineer, Edward G. Budd Mfg. Co., said that when the weights are comparable the strength values are not. The Budd Co. uses stainless steel, aluminum alloy, wood, plastics and low-alloy steel, arc welded but stress relieved. They find a use for everything in its place and feel that price alone should not determine where it should go.

D. C. Turnbull, Jr., executive assistant, Baltimore & Ohio Railroad, emphasized the need for a different class of design for commuter-service equipment as compared with cars for long distance travel.

—*Railway Age*, Vol. 120, Jan. 12, 1946, pp. 142-152.

Will She ask for YOUR PRODUCT?

One way to assure consumer demand for your product is to make use of the valuable properties of glass wherever possible. Housewives need not be sold on glass. Their years of experience with it have taught them the value of its utility, cleanliness and permanent luster. Recently they have learned to respect its durability as well.

Many design engineers have given added sales appeal—improved performance—to a product by the use of glass. Others have, by means of glass, created products which would otherwise have been impossible. Perhaps you, too, can take advantage of the consumer acceptance of glass.

THOUSANDS OF TYPES OF GLASS

From the thousands of glass formulae developed by Corning Glass Works, you can secure the one with the combination of properties which meets the specific requirements of your product. Corning Engineers are ready to give you the benefit of their years of experience in selecting the glass best suited for your particular use.

CORRECT DESIGN IS IMPORTANT

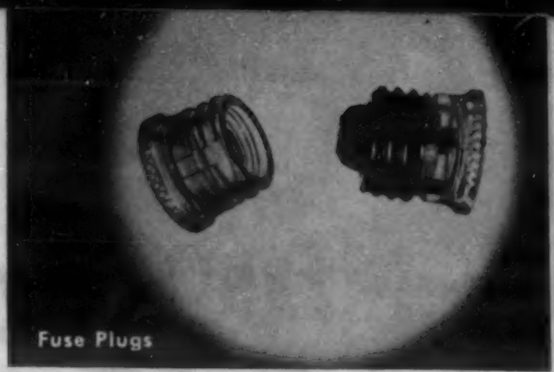
The vast knowledge and experience of Corning's Product Engineering Department in the development of more than 40,000 different glass products provides a valuable source of data on which to base new designs. Corning can assist you in designs that will make full use of all the valuable properties of glass.

PRODUCTION FACILITIES

Whether your requirements call for a single glass part of intricate design or thousands of similar parts, Corning has the engineering and manufacturing facilities to help you. Manufacturing techniques permitting the automatic production of glass parts in quantity and at low cost also assure you of uniform quality. Glass can be pressed, blown or drawn either by hand methods for small quantities or by high speed, automatic machinery. Precision tolerances can be secured by carefully controlled finishing operations.

Corning Engineers will gladly help you to select the best glass for your particular purpose. They have the glass knowledge—the "know-how" of design and production. It is available to you for the asking. Write to the Industrial Sales Dept. MM-4,

CORNING GLASS WORKS
CORNING, NEW YORK

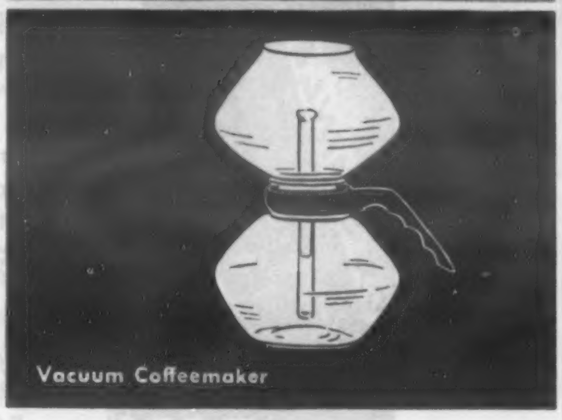


Fuse Plugs

Pyrex Skillet

Mixing Bowls for Hamilton Beach Food Mixer

Iced Tea Urn made by Cecil Manufacturing Company



Vacuum Coffeemaker

CORNING — means — Research in Glass

INDUSTRIAL GLASS by CORNING

"PYREX" and "CORNING" ARE REGISTERED TRADE MARKS AND INDICATE MANUFACTURE BY CORNING GLASS WORKS, CORNING, N.Y.

INDUSTRIAL SALES DEPT., MM-4
Corning Glass Works, Corning, New York

Please send me a copy of your Bulletin IZ-1—
"Industrial Glass by Corning."

Name.. Title..................

Firm...

Street...

City and State...

Fatigue Failures of Aircraft Parts

Condensed from "Aeronautical Engineering Review"

Basically, a fatigue failure is the result of one or more of the following factors: stress concentrations, deflections, and vibration. This discussion is limited to fatigue failure of parts of airplanes in service and limited further to primary structure parts. The theory of such failures is slippage of the individual crystals of a piece of metal under load.

When the stresses are low, only a few crystals are disarranged with each loading and, therefore, the number of loadings is a function of the magnitude of the load. If the load is applied many times, sufficient slippage occurs to cause a crack.

Effects of fatigue loading are cumulative. "Rest" periods between periods of loading do not increase the number of applications of load a part is able to endure. A sheet metal part, subjected to compression load, may buckle slightly. At the buckle the stress starts out as compression; then, as the height of the buckle increases, the stress on the outside reverses itself to tension because of the local bending of the sheet. The reversal may occur at an edge which may already have many tiny nicks and extremely low endurance results.

An extreme example of vibration effects was that of a hand-crank extension for an engine starter. Its only load was its own weight, 1½ lb. The bolt is ¼ in. in diam. but the hole was erroneously drilled $^1/_{16}$ in. oversize. After 100 hr. of engine operation the part failed.

One of the serious drawbacks to designing for the elimination of fatigue failure is the lack of established standards as to the stress range and the number of cycles of loading a part should withstand. In designing for airplanes, one must always remember weight, for some part too good might be too heavy.

One airplane manufacturer has gone far in designing parts to just last the natural life of the airplane as a whole. One of the great sources of trouble encountered in all types of aircraft occurs in the empennage and its fittings.

On one model failures began occurring after about 2000 hr. of flight. The vertical stabilizer rear spar attachment to the fuselage would crack, starting at a free edge of 0.051 aluminum alloy and would progress rapidly until complete failure took place. If not caught in time, it would mean the loss of the airplane.

Tests of the above were made which duplicated the failure in service. Failure took place after 2000 reversals of applied load. The failure was identical with that which took place in service. This is equivalent to one load application per hr. of flight.

The stresses involved were relatively small, but it was noticed that the sheet would buckle at the edge between the bolts at the point where failure took place. This caused a bending back and forth of the material, giving extremely high reversals of stress due to the local buckling. Tool marks and other nicks accelerated the start of the failure. Finally, flanges were added to stiffen the edge.

—D. M. Davis. *Aeronautical Engineering Rev.,* Vol. 5, Jan. 1946, pp. 15-23.

MELTING and CASTING

Melting, alloying, refining and casting methods, furnaces and machines. Iron and steel making, nonferrous metal production, foundry practice and equipment. Die casting, permanent mold casting, precision casting, etc. Refractories, control equipment and accessories for melting furnaces.

Advances in Steel Castings

Condensed from "The Foundry"

The urgent need for steel castings during the war served to dispel some old prejudices and give impetus to the use of new techniques in the castings industry. Many iron foundries converted to steel by the acquisition of side blow converters to blow the cupola iron and, as a result, the antagonism toward converter steel was largely dispelled. Belief that good quality cast armor could not be made in the basic open-hearth was also proved to be without foundation.

To produce castings of the highest quality, the principles of directional solidification and atmospheric pressure feeding were widely employed; new attention was given to sand conditioning and to sand testing, particularly at elevated temperatures. An outstanding advance was made in the use of centrifugal force to shape and feed castings. True centrifugal casting and centrifuging found many new applications, and precision casting methods found new fields of usefulness.

More extensive use of water quenching of castings, even of large castings, was widely employed to obtain better strength-weight ratios. Castings were made to specified hardenabilities, the hardenability data obtained from wrought steel being applicable to castings. During the war the trend in specifications was toward specifying properties and the requirements of the product, leaving the composition and method of manufacture to the producer.

The emphasis on quality of the steel castings during the war years created a demand for more searching methods of inspection. The present widespread use of X-ray and magnetic powder testing was a war-time development. The million volt X-ray machine was promptly put to use in steel castings inspection.

The list of products developed as steel castings during the war years is long.

1. Cast tank armor, which has the advantage over rolled and welded construction of being adaptable to streamlining, thus making the tank less vulnerable in addition to improving its appearance. Turrets with sections up to 6 in. were in production at the end of the war.

2. Cast steel breech rings were developed at the time of the critical shortage of forging capacity and machine tools. This development not only relieved the forging situation, but the rings could be cast to close dimensions with savings in machining.

3. Centrifugally cast aircraft engine cylinders, which proved to be at least equal in quality to the forged sleeves.

4. Cast rotors and stators for superchargers, which was probably the most difficult development of all. These were made of high heat resisting steel by precision casting methods and resulted in the saving of many man-hours of labor through elimination of a large amount of welding, and improved the efficiency of the assembly.

—C. E. Sims. *Foundry*, Vol. 74, Jan. 1946, pp. 76-81, 220, 222, 224-225.

Sealing Bronze Castings

Condensed from "The American Foundryman"

Although it has been found that leaky castings of gun metal, valve bronze and hydraulic bronze may be made pressure tight by heat treatment under certain circumstances, it is believed that the practice of annealing bronze castings for the sole purpose of improving pressure tightness is a questionable expedient until such time as records may be obtained on the performance of sealed castings in service.

The repairing of leaky castings by heat treatment has aroused interest because it is considered to be clean, rapid and fairly effective. In the present investigation, 34 bushings of gun metal, valve bronze and hydraulic bronze were cast in a manner intended to produce leakage in a hydraulic pressure test. The pressure at which the bushings began to leak was recorded after various sealing experiments. The changes in microstructure and mechanical properties resulting from heat treatment were also investigated.

The pressure tightness of leaky bushings was improved when they were annealed for 3 hr. at 1200 to 1300 F in an air or oxygen-rich atmosphere. No sealing whatever took place in a hydrogen atmosphere.

When bushings previously improved in pressure tightness by annealing in the oxygen-rich air were reannealed in hydrogen, the pressure tightness decreased by 25 to 50%. Removing the outer layer of oxide scale after sealing in air did not cause appreciable loss in pressure tightness, provided that the bushings were annealed for 3 hr. at the necessary temperature.

The bronze specimens used in this investigation were sealed by the formation of oxides of larger specific volume than the base metal. The oxide layer on the inside of fine shrinkage cracks tended to close the openings provided that the cracks were of sufficient fineness. The tendency for leakage of unsound bronze may become serious after several years of service, and


Lectromelt

the wear resistance of moving parts is certainly lower with unsound metal.

The short-time pressure test at room temperature is not equivalent to conditions of service. It is believed that the annealing of leaky bronze castings to improve pressure tightness should be exercised with care until such time as information may be obtained over a period of years on the performance of sealed castings in service.

—F. L. Riddell. *Am. Foundryman*, Vol. 8, Oct. 1945, pp. 24-29.

Progress in Aluminum Castings

Condensed from "The Foundry"

The two outstanding wartime developments in the aluminum foundry industry were the enormously increased production and the extension of highly specialized techniques of quality casting production to the smaller foundries. Within these two developments there has been progress in mechanization, technology and inspection.

The most remarkable wartime development was the expansion in the productive capacity of aluminum foundries. Privately owned casting capacity increased approximately 7 to 8 times over the 1939 capacity. With the exception of cast cylinder heads produced in government-owned plants, most of the castings produced during the war were made in private plants. All of the permanent mold and die castings made in 1944 as well as 92% of the sand castings were made in commercial plants.

The extension of specialized techniques into the smaller foundries has helped place the entire industry on a firm basis. The quality of castings was improved with the result that castings were specified where formerly forgings were required. Mechanization of foundries has resulted in savings as well as in increased production.

Degassification of all alloys with barium chloride has become standard practice, resulting in improvements in soundness and grain size. High purity alloys have been found to be more corrosion-resistant. Aluminum-magnesium alloys have found wider application since handling techniques were mastered. The quality of the standard alloys, such as Alcoa 195, 355 and 356, has been improved.

Radiography, fluoroscopy and "black light" inspection methods were improved and found more widespread use. Microradiography was developed into a fairly useful tool.

Permanent mold and die casting processes received considerable impetus during the war. Centrifugal casting of aluminum is still in the experimental stage. The use of plaster molds and cores has increased considerably. Electric melting processes have been adapted for use in aluminum foundries, but the high initial investment in equipment is still the main deterrent to the widespread use of induction melting equipment for aluminum.

After reconversion is well under way, the aluminum foundries should find that the developments of the war period will be helpful to the whole industry in supplying old markets with better and cheaper products.

—L. W. Eastwood. *Foundry*, Vol. 74, Jan. 1946, pp. 82-86, 165-166.

FABRICATION and TREATMENT

Machining, forging, forming, heat treating and heating, welding and joining, cleaning and finishing of solid materials. Methods, equipment, auxiliaries and control instruments for processing metals and nonmetals and for product fabrication.

Induction Heat Treating Internal Surfaces

Condensed from "S.A.E. Journal"

To heat treat the internal diameter of a thin-walled body successfully, the heat must be applied at a very high rate for a very short time. It has been determined experimentally that in steel such as S.A.E. 1045, if brought up to the required temperature, complete homogenization of the carbon can be secured in a heating time of about 1 sec.

Heating is accomplished by concentrating high-power, high-frequency currents in the zone to be hardened so that the temperature of the zone is raised to the hardening temperature before any substantial amount of heat can drift to the core of the piece.

The static, or one-shot, machine heats the entire area to be treated at one time. It can heat treat areas in a bore less than 5 in. diam. and 6 in. long. It requires a large generator capacity to treat the large bore dimensions.

The progressive, or scanning, type of machine usually is more desirable where the body is cylindrical in form, open at both ends, and longer than 6 in. These machines are equipped with heat-treating heads of relatively short length—1½ to 3 in., and normally heat treating at rates of 1 to 3 in. per sec. A quench head is arranged to quench the work piece immediately upon the heated zone's reaching the proper relation with the quench head.

Among the electrical parts of the machine are a motor-driven, inductor alternator; exciters; solenoid or air-operated contactor; metering equipment; two-conductor, lead-sheathed, concentric stranded cable; sliding-core switching transformer; conducting arbors; and tuning condensers. A suitable work-holding fixture is provided.

The heat-treated head consists of a tubular copper coil wound about a laminated iron core, all mounted on a mandrel. Cooling water is circulated through the coil. The quenching device is placed directly below the heat-treat head and is maintained in definite relation to it. The quenching device is retracted from this relation during the loading and unloading period, by means of an air or hydraulic cylinder operating in timed and controlled relation to the other operations.

All the timed sequences are maintained by means of a controller consisting of a series of precision cam-operated switches. It is designed to give extremely high fidelity in timing of the controlled operations and to permit change-overs for treatment of different sizes of bores within a minimum amount of time.

A suitable motor-driven hydraulic system controls the movement of the work-holding fixture and heat-treat head. The transformer primary and secondary, and all connecting arbors, are water cooled. A great deal of stainless steel and bronze are used in the machines to avoid rust or corrosion. These machines are fully automatic, the only requirement being that the operator place the work piece in the holding fixture.

Among the many applications of internal induction heat-treatment are auto and truck parts, gasoline and Diesel engine parts, gears, bearing races, etc.

—H. E. Somes. *S.A.E. Journal*, Vol. 54, Feb. 1946, pp. 45-54, 63.

Selective Heating and Fatigue Failures

Condensed from "Industrial Gas"

There is increasing interest in selective heating by induction or by the new furnaceless technique using gas. The tendency has been to apply these methods somewhat promiscuously in the heating of machine parts where it seems advantageous to eliminate the heating of the entire part.

The selectively hardened part may have satisfactory wear resistance but may show more fatigue failures than conventionally hardened parts, due to the effect of selective heating on residual stresses. Nitriding, carburizing or the severe quenching of shallow hardening steel gives a more favorable stress distribution from the standpoint of fatigue resistance than selective hardening.

However, selective heating is applicable

with considerable advantage where no tension stresses are involved or where the design is such that the tension stresses are low. The selective heating of parts highly stressed in tension should be approached with a great deal of caution. For example, in highly stressed gears, the fatigue failure always occurs at the root of the tooth on the load side of the tooth. As far as we can see now, such a gear should be carburized.

The fact that thousands of gears and crankshafts have been successfully hardened by means of selective heating with induction or gas indicates merely that in these cases the parts were not too highly stressed at the vulnerable points.

—C. H. Lekberg. *Industrial Gas*, Vol. 24, Dec. 1945, pp. 13-14.

Diamond Forming of Grinding Wheels

Condensed from "Machinery"

Crush forming of grinding wheels provides a method by which irregular shapes and forms on grinding wheels can be quickly and economically produced and the form can be reproduced as often as required. A new method is described using diamonds instead of the usual steel crushing rolls.

In the case of two 90 deg. V-ridges to be ground on a flat piece of hardened steel, the actual cost of diamonds and the steel rolls was about the same. The diamond gave a slightly better finish. Also, the diamond lasted 40% longer than the steel rolls.

Diamonds will stand more abrasion than steel but they are a great deal more brittle. This disadvantage can be partly overcome by careful examination and choice of the diamonds. It is particularly important that they contain no flaw lines. The use of diamonds with an angle of less than 90 deg. is not advised as there is not sufficient body to give the necessary strength.

Sharp edges on the diamond will tend to crumble when exposed to the grinding wheel. To prevent this, as many facets as possible should be polished on the upper part of the diamond. As one facet wears, the diamond can be reset with another facet facing the wheel. The diamond should be fed slowly toward the wheel until actual contact is made before the crushing is started.

—H. L. Strauss, Jr. *Machinery*, Vol. 52, Jan. 1946, p. 179.

British Practice in Heat Treatment of Wrought Aluminum Alloys

Condensed from "Modern Machine Shop"

In the heat treatment of aluminum alloys, it is necessary to pay strict attention to details. Some alloys are work hardenable while others may be hardened by heat treatment. The hardening of the latter alloys consists of three steps: heating to the solution temperature, cooling rapidly, and aging.

The solution temperature should be as

high as possible for maximum hardening, but the upper temperature limit is set by the occurrence of partial melting. Suitable soaking times should be found by test as prolonged heating of aluminum coated sheet is especially harmful. A cold water quench is normally used for the rapid cooling, but it may cause excessive distortion. The distortion may be minimized by the use of a slower cooling medium (hot water, oil, air blast or water spray), but the corrosion resistance of certain alloys may be harmed by the use of these media.

The period between the solution treatment and quenching is likewise very important. The common practice in England is to use cold water in all cases except for heavy forgings, where boiling water or oil is used. Certain alloys are aged at room temperature, while others require heating to 265 to 390 F. The aging time in the latter case is a function of the exact temperature used.

Work hardenable alloys may be annealed by heating above the recrystallization temperature. Excessively high temperatures and long holding times should be avoided, as they will lead to grain growth. Rapid heating is desirable as it minimizes grain growth. Work hardened, heat treatable alloys may be annealed after cold work by holding at 645 F for 1 hr. and cooling slowly to avoid susceptibility to age hardening.

The same treatment generally provides adequate softening for fully heat treated alloys. However, if special softening is required, the alloys should be held 1 hr. at 750 to 795 F, and cooled at 27 F per hr. to 610 F. The longer the soak and the slower the cool, the greater the amount of softening.

Over annealing is not desirable, especially with aluminum clad material, where the resulting diffusion will decrease the corrosion resistance.

—E. R. Yarham. *Mod. Machine Shop*, Vol. 18, Feb. 1946, pp. 146, 148, 150, 152, 154, 156, 158, 160.

Materials for Electroplating Tanks

Condensed from "Metal Finishing"

The ideal material for the construction of an electroplating tank would be electrically nonconductive, would withstand heat, physical abuse and chemical attack, and also should have a low first cost. Some of the types of commonly available tank materials are described in this article.

Where steel is used for tanks of 500 gal. or more capacity, ¼-in. hot rolled open hearth sheet is a common material, with lighter gages being used for the smaller tanks. End and bottom joints are electrically welded on the inside and outside, and an angle iron is usually welded around the top to stiffen the edges.

The cost of a plate steel tank averages $1.25 per. sq. ft. of inside surface area. Linings of pitch, asphalt and other similar coatings are inexpensive but not entirely satisfactory when applied over the scale of hot rolled sheet; peeling and break down at pores generally develops.

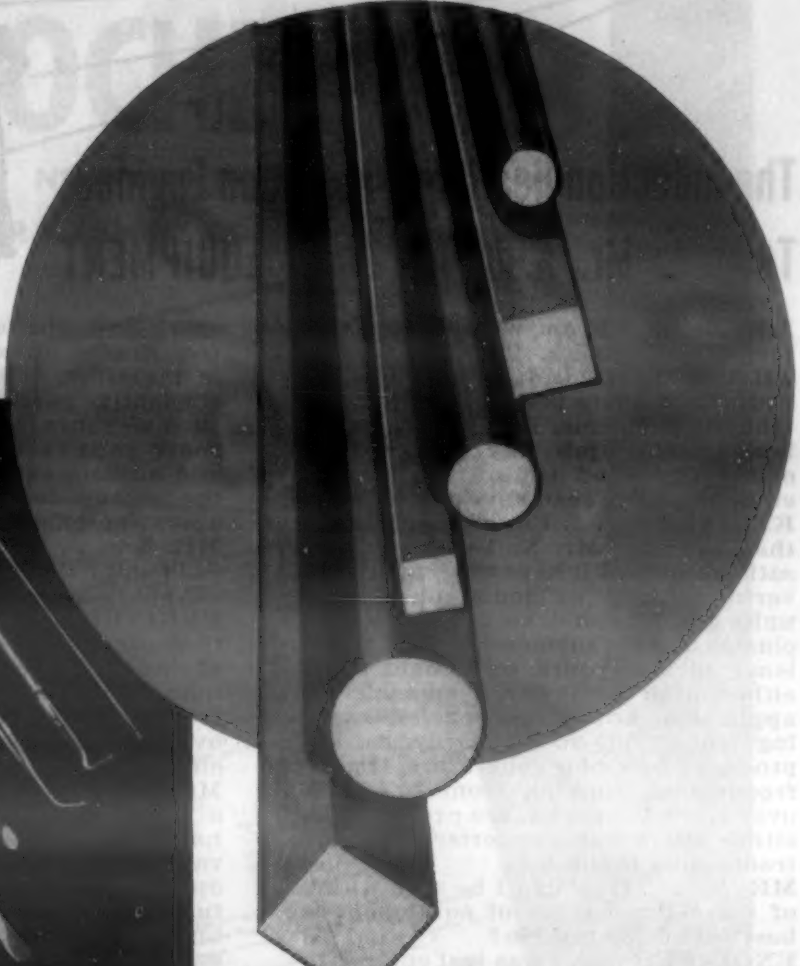
Wood tanks are usually made of cypress, red wood or a fir with steel tie rods. The cost of this type of tank is about 50%

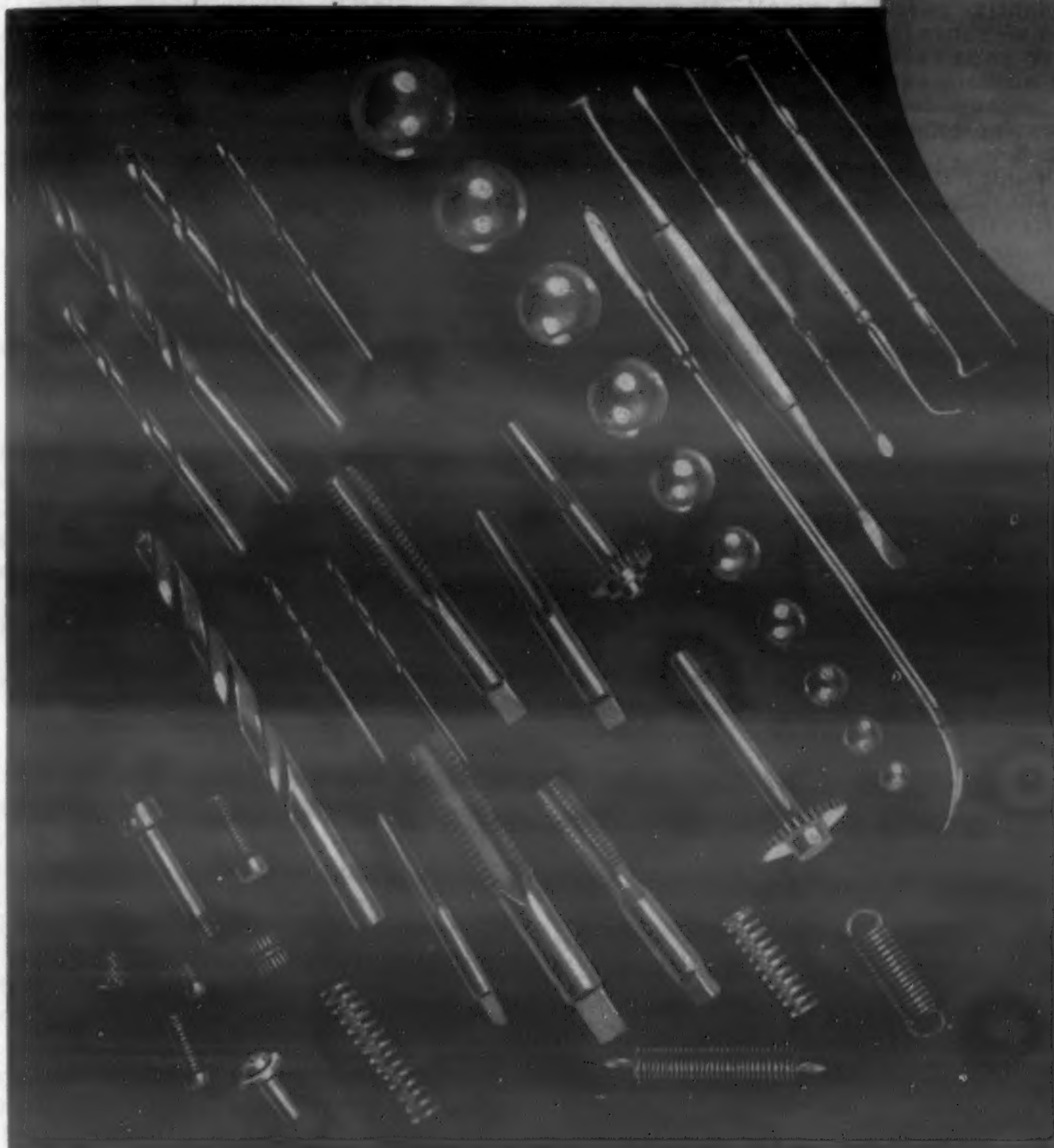
GLOBE DRILL ROD

a

FIRTH STERLING

Product





Available in High-Speed Steels, Tool Steels, Stainless Steels—in Bar, Rod and Wire. It is supplied in various finishes—polished, ground, and rough drawn or rough ground. "A Uniformity of High Quality."

GLOBE WIRE DIVISION

Call **Firth-Sterling**

STEEL COMPANY

McKeesport, Pa. • New York • Hartford • Philadelphia • Pittsburgh • Cleveland • Dayton • Detroit • Chicago • Los Angeles

greater than for steel, and where Monel tie rods are used, the cost is further increased. Unlined wood tanks are generally used and are preferred for rinses.

Linings such as lead or stainless steel are not too common for wood tanks; steel tanks may be lined with these materials, however. Pitch lined wood tanks are widely used for room temperature nickel plating, being low in cost and electrically nonconductive, but are not suitable for alkaline solutions.

Solid-wall synthetic resin (having asbestos or carbon filler) tanks cost ⅓ more than the comparable rubber lined steel tank. They can withstand temperatures of 265 F with mineral acids up to 50% in strength. Solid wall glass tanks made of heat treated glass plate are stronger than ordinary plate.

Sudden temperature changes and mechanical shocks are liable to be very damaging to ceramic or chemical stoneware, though thermal shock-resisting ceramic materials are available. Unlike chemical stoneware, crocks are not impervious, soaking up solution they contain and forming salts on the outside.

One-eighth-in. thick lead sheet is commonly used for lining steel tanks, the cost being low. For chromium plating tanks, a lead lining containing 7% tin has good chemical resistance, and the widest application of lead lined tanks is for this type of work.

Enameled tanks or pots are best for alkaline solutions. Rubber has proved the best all around material for lining tanks, but continued operations above 160 F are not recommended. Synthetic resin type linings find increased use despite costs of approximately 40% above rubber.

Chief advantage of carbon brick-lined steel tanks are in their resistance to attack by mixtures of hydrofluoric and nitric acids used in pickling aluminum and stainless steel.

—J. B. Hogaboom, Jr. & Nathaniel Hall. *Metal Finishing*, Vol. 44, Feb. 1946, pp. 63-66.

Forging Aluminum Aircraft Pistons

Condensed from "Machinery"

The Buick Motor Div. of General Motors Corp. has developed a method for forging aluminum alloy aircraft engine pistons that differs greatly from the usual upset method employed by other manufacturers. It involves the use of a forging press of 2000 tons capacity.

The aluminum alloy is received in the form of round bars 3½ in. in diam. by 10 ft. in length. These bars are cut up into lengths of 7½ in. by employing an abrasive sawing machine. There billets are weighed to insure uniform accuracy and then polished to remove sawing burrs.

The billets are then placed in a conveyor type furnace which operates at a temperature of 850 F, and remain in the furnace for approximately 3½ hr. Next, they are placed directly in a die on the forging press and with one stroke of the press they are formed into a truncated cone shape. This cone-shaped piece is then rough blocked into the piston shape by a second die and a second stroke of the press. A saline solution sprayed on the punch pre-

(Continued on page 1097)

vents the heated billet from sticking to the forming tool.

After the rough-blocking step, the forming tool holder, which carries two forming tools, moves into the second position on the press. The piston is finish-blocked in the same die as the one in which it was rough-blocked by a third stroke of the press. The actual time for the three strokes is less than 20 sec.

After forging, the pistons are placed on trays, single depth, and allowed to cool to room temperature during a period of about 5 hr. They are then treated and inspected. The pistons are then subjected to a temperature of 625 F for 1 hr. in a conveyor type gas-fired furnace, after which the skirt of the piston is closed by an Ajax 1000-ton press.

Now the pistons are ready for heat treatment. Four hundred pistons are placed in a cylindrical basket, and this is placed in a furnace for 10 hr.—6 hr. at least at 960 F. They are then quenched and aged at 340 F for 7½ hr. Following this treatment, the pistons are cleaned, tested, and inspected, and are ready for machining.

—C. O. Herb. *Machinery*, Vol. 52, Nov. 1945, pp. 149-152.

Measurement of Temperatures in Metal Cutting

Condensed from "Transactions" of the American Society of Mechanical Engineers

Boston and Kraus evaluated cutting temperatures when machining an annealed low-carbon steel in a lathe at cutting speeds between 20 and 320 fpm. A constant chip depth of 0.150 in. and 0.030 in. feed were used. The cutting temperatures were measured with a thermocouple arrangement in which one element was the tool and the other the workpiece. These were calibrated in a furnace and the temperatures evaluated in millivolts.

An increase in temperature from 650 to 900 F was noted between 56 and 115 fpm. cutting speed. For the cutting speeds between 115 and 320 fpm., cutting temperatures varied between 900 and 1000 F, the latter at a cutting speed of 210 fpm. Chip temperatures were determined from temper colors.

Little variation was observed for speeds between 100 and 320 fpm., the authors concluding: "The temperature of the chip as determined by temper colors was changed less than 5% in the range of cutting speed from 90 to 320 fpm."

Chip temperatures were almost constant at the higher speeds, which is not true of the lower speeds. At a low speed the workpiece and tool will conduct away a higher percentage of the heat generated in the chip because of the slow separation of the chip from the workpiece.

The temperature of the tool is much higher at higher speeds than at low speeds because the work done per unit time is much greater. Thus, a tool will generally remove a greater amount of metal at low cutting speeds before failure than at high speeds.

Most of the work expended in metal cutting is carried away as heat by the chips; the remainder is absorbed by the tool and

workpiece. The heat in the tool is of greatest importance because it is the accumulation and concentration of intense heat at the cutting edge of the tool which hastens failure. It is evident that the amount of metal removed before tool failure will generally be inversely proportional to the cutting speed when the chip cross section is kept constant, and, despite the chip temperature, will remain substantially the same.

Assuming an ideal case in which the tool does not wear and thus change the cutting forces, the same volume of tool metal has to dissipate twice the amount of heat per unit time when the cutting speed is doubled.

If all conditions are kept constant except cutting speed, the following conclusions are logical: The temperature of chips of uniform cross section remains approximately the same in the high range of cutting speeds; the temperature of the cutting edge of the tool increases with the cutting speed; the temperature of the workpiece is lower at the higher cutting speeds.

—A. O. Schmidt, O. W. Boston & W. W. Gilbert, *Trans. Am. Soc. Mech. Engrs.*, Vol. 68, Jan. 1946, pp. 47-49.

Electronics Applied to Machine Tools

Condensed from "The Tool Engineer"

This article is concerned with the application of the electronically-controlled speed drives to machine tools. The business end of the drive is a shunt-wound, direct current motor. It consists of a field winding that is stationary and a wound armature which rotates and converts electrical energy to mechanical power.

Since the power conversion takes place in the armature, that circuit takes 97 to 99% of the power supplied to the motor, the balance consumed by the field circuit. The field and the armature, connected in parallel to a direct current source, is a constant speed device.

One can vary the speed of this motor in two ways: (1) The field control method, in which the speed of the motor increases as the voltage across the field is lowered. The torque decreases at the same rate as the speed increases, resulting in a drive with constant horsepower output; (2) to maintain constant voltage on the field and vary the armature voltage, called armature control.

With the field voltage maintained constant and the armature voltage lowered, the motor speed decreases directly with the armature voltage. With field strength and motor torque constant, the horsepower output of the motor decreases directly with the speed.

By combining armature and field control, the speed range of the shunt motor is 100 to 1. There must be two sources of power for the motor, each of which must be independently adjustable. Controlled conversion of a.c. to d.c. by electronic means lends itself most easily to automatic control. The electronic key is a gas-filled, grid-controlled tube, the "thyratron."

A very minute amount of power applied on the grid will control relatively large amounts of power through the anode circuit. Output voltage can be adjusted from zero to maximum. Usually a pair of small

thyratrons supply the field circuit and a pair of larger thyratrons, the armature power.

The actual control medium which must be actuated to vary the speed of the drive is very simple. It may be a potentiometer the size of the volume control on an ordinary radio receiver. The ability of the grid to control the flow of current in the thyratron provides the electronically controlled adjustable speed drive with the following advantages over other types of drives:

There are suitable adjustments to limit maximum current the motor will take, usually between 100 and 200% of the full current load. Current limit control provides smooth acceleration because 150 to 200% torque is continuously available. The speed regulation of the drive is very good. Thus, as the load on the motor increases, the normal tendency of the motor to slow down is counteracted by a slight increase in armature voltage, making for constant speed. The small size of the potentiometer is good where speed control must be built into the machine.

—B. T. Anderson. *Tool Engineer*, Vol. 16, Feb. 1946, pp. 34-41.

Bright Hardening of Tools and Machine Parts

Condensed from "Machinery"

The designers of machine parts and tools can use the recent developments in bright hardening to eliminate finishing and cleaning operations after hardening. The use of this process in machine tool production may result in considerable cost reduction and at the same time allow closer control of quality and uniformity.

If decarburization is to be avoided, the carbon dioxide and water contents of the atmosphere must be low. There are various methods of accomplishing this, but the one discussed here involves the complete reaction of the proper air-gas mixture by controlled heating in the presence of a catalyst. The proper atmosphere is produced economically, continuously and directly, and a special muffle is not required. The atmosphere can be brought into approximate chemical balance with the surface of a wide range of steels by a simple adjustment so that neither decarburization nor oxidation occur.

The carbon potential of the gas atmosphere is determined by heating a fine steel wire in the gas until a carbon equilibrium is obtained between the hot wire and the gas. Then the wire is cooled suddenly to form martensite, the electrical resistivity of which is a sensitive measure of the carbon content of the wire.

The higher the heating temperature, the closer must be the control of the carbon potential of the atmosphere. At the high temperatures required for high-speed steel, the atmosphere must be virtually in chemical balance with the steel. High-speed steels require high carbon potentials if decarburization is to be avoided.

In many applications, a slight oxidation is not important if no decarburization occurs. However, if steels containing large

amounts of chromium are to be truly bright hardened, dissociated ammonia is the only atmosphere that can be used.

—C. E. Peck. *Machinery*, Vol. 52, Feb. 1946, pp. 158-163.

Protective Packaging

Condensed from "General Electric Review"

Much was learned during the war of packing and packaging war materials that must not only stand up against rough handling and corrosion in the extremes of the arctic and tropics but even in the temperate climate of the United States. Before efficient packaging techniques were developed, losses from spoilage in overseas shipments often ran from 25 to 50%.

The three fundamental types of packaging which were evolved during the war are: Corrosion-preventative compound, called Method I; waterproof protection, called Method I A; and moisture-vaporproof protection, called Method II.

Corrosion-preventive compound protection consists of thoroughly cleaning a surface of all contamination and applying a corrosion-preventive compound which may have a consistency ranging from that of light oil to that of heavy grease or asphalt paint, depending on the degree of protection required. An extra protection is often a grease-proof, acid-free wrapping material, used on metallic parts of simple shape, particularly steel parts.

Thorough cleaning of the part to be protected is extremely important. An unclean surface will produce a blush, or cracking and peeling. If corrosion-preventive compounds are applied over unclean surfaces, corrosion may take place underneath the compound.

Fingerprints produce special salts and acids from the body that are not removed by the petroleum-type solvents used for ordinary dirt. Synthetic methanol is excellent for fingerprint removal, but because of its toxicity and low flash point special precautions must be taken.

New compounds with higher flash point and lower toxicity than methanol have been developed that are a combination of fingerprint remover, water displacer and temporary (indoor exposure) corrosive-preventive compound. They are useful for items before assembly in the factory, too, such parts as small nuts, bolts, gears, shafts, pins and sleeve bearings. Heavier type compounds are used for protection during storage and shipment of larger, heavier items, such as gears, steam and gas turbine rotors and motor shafts.

Method I A consists of a water-resistant wrap around the part. Among the vehicles for its use are the carton overwrap, and the sealed case liner. Each requires special materials, such as asphalt spray coats, asphalt-Kraft laminations, metal foil-Kraft laminations, cellulose or vinyl sheetings and waxed-paper or waxed-cloth laminations. Also there are hot dip plastic compounds, called Method I B.

Moisture-vaporproof packaging is obtained by providing an atmosphere of low relative humidity surrounding the parts by use of a dessicant or dehydrating agent. Tin can shipping containers protect from

corrosive influences and handling. Where material is boxed in green lumber, the moisture from the wood is provided for by openings or ventilating holes to allow the lumber and any accumulating moisture to dry out.

—O. C. Rutledge. *Gen. Electric Rev.*, Vol. 48, Dec. 1945, pp. 16-19.

Comparison of Electric and Gas Silver Brazing

Condensed from "Machinery"

The basic variations from conventional gas-air heating apparatus which have been responsible for recent progress in the development of gas-air combustion equipment involve a new technique of premixing the gas and air from a combustion controller which delivers the mixture at relatively high pressures. In applying the mixtures, heat is transmitted to the work by one of three burner types or modifications of them.

The first burner type—superheat combustion—confines completely the combustion reaction within a small insulating refractory chamber with a restricted outlet opening, 50 million Btu. per cu. ft. of combustion space per hr. can be liberated.

The second burner type—radiant combustion—differs in that the radiant energy is directed at the work and the combustion is not confined.

The third type—ceramic screen combustion—is a development of the traditional drilled metal plate type of burner.

No one heating device or method is the answer to all silver-brazing problems. For work quality, where an adequate joint is the first concern, either induction or gas-air heating may be used. High frequency induction units often heat too rapidly if proper control is not exercised, resulting in pin-hole joints.

The quantity of work produced will depend on the size of equipment. Induction equipment presents less flexibility in size and cost than does the gas-air equipment, especially when small quantities are involved. This is due to the high cost of the electronic equipment.

Labor costs are considerably higher for the operation of the induction equipment, requiring at least one operator for each machine. Gas-air equipment manufacturers have reduced labor costs to a minimum by supplementing the energy system with mechanical, continuous work movement means.

In the case of the silver-brazing of multiple joints in a steel tubular assembly, the cost of producing the required heat was 0.7 cents per unit for gas-air heating, and 5 cents per unit for induction heating. The initial investment for an equal amount of production was far greater for induction heating than for gas-air heating.

Maintenance costs comparisons can be determined by the fact that gas-air equipment can be repaired or maintained by shop mechanics, whereas a trained engineer would be advantageous to handle failures of induction equipment. The greatest maintenance cost of gas-air equipment is for burners.

—P. F. Berg. *Machinery*, Vol. 52, Jan. 1946, pp. 151-154.

METHODS AND PROCESSES

TESTING and INSPECTION

Testing methods and equipment for physical and mechanical properties, surface behavior and special characteristics. Radiographic, spectrographic, identification, metallographic, dimensional and surface inspection. Stress analysis and balancing. Specifications, standards and quality control.

Radiographic Inspection and Foundry Operations

Condensed from "Industrial Radiography"

The use of radiographic examination by both the producer and the customer is for the same purpose—acceptable soundness. X-ray equipment enables the producer to develop extremely complete information without resorting to destructive testing. Production or pilot castings may be examined and then subjected to additional tests, such as hydrostatic, proof or field destruction tests. Furthermore, the producer has a permanent record to show or compare progress.

No two foundries produce the same type of casting by identical practices. Satisfactory and unsatisfactory castings may be produced in the same foundry. Therefore, the producer aims first for the standardization of all recognized variables and utilizes radiography. He is then in a position, if necessary, to change one variable at a time until the desired result is obtained. Each casting is an individual problem, and the technique of radiographic examination can be one of the most useful tools the producer has.

Purchase specifications govern the use of radiography. The "Radiographic Standards for Steel Castings," issued by the Bureau of Ships, Navy Department, are to be used as the basis for acceptance of certain types of castings inspected by the Navy. The American Society for Testing Materials has prepared a tentative specification for certain types of products, and foundries may be required soon to produce commercial castings in accordance with its provisions.

Many progressive producers have recognized the interlocking of metallurgical and inspection interests. The producer utilizes radiography as a production tool and the customer can obtain, or is provided with information which will assure him as to the quality of the casting.

If a casting is of a type covered by existing standards of radiographic examination, the areas to be examined are specified. Otherwise, the producer and customer by joint agreement, select them. In critical types, a 100% examination may be made on the first few or all of the castings. Field examinations must be continued until it is established that the defects disclosed through X-ray examination are of known effect.

The producer and customer must recognize that their first problem is the development of suitable standards of acceptance which will represent good average practice for the design. Sound metal permits the use of a lower factor of safety and makes it possible to reduce the section. Metal added to compensate for unsoundness penalizes the customer.

The radiologist is concerned primarily with the techniques of making exographs. It is important that he knows something of foundry, metallurgical and inspection work and the requirements of the casting involved. When standards are available, judgment of casting quality is made easier. Each type of recognized defect is given in the standards and these are classed according to the type of casting involved and the acceptance level of the defect. Any defect equal to or better than "borderline" in any 5 by 7 in. area is considered acceptable. When two types of defects are present to an extent equal to the "borderline" standard for each type, all "borderline" defects shall be considered unacceptable.

Castings rejected may be repaired, providing this is economically feasible, by welding. Approved welding methods must be used, and the acceptability of the repair

welds shall be determined by comparison with the radiographic standards of the Bureau of Ships for Class A-1 welds.

—T. E. Caldwell. *Ind. Radiography*, Vol. 4, Fall 1945, pp. 28-30.

Gas Testing Devices

Condensed from "Industrial Heating"

A group meeting on instruments for quality control at the National Metal Congress, Cleveland, in October, 1944, considered the following subjects: Process and combustion gas analyzers, a dew point potentiometer and recorder, use of flow meters in steel plant operations, furnace-pressure meters and controls, and gas-mixing and fuel-air ratio controls.

A minimum of excess air is desirable for complete combustion, but some excess is necessary to offset incomplete mixing of fuel and air and other factors. Too much excess air lowers the furnace temperature and raises stack losses, since the air must be heated, but does no work.

Cement kilns can operate with as little as 1% excess air, while well-operated heating furnaces can operate with about 5% excess. Carbon monoxide and hydrogen in the flue gases indicate incomplete combustion and can be measured by instruments continuously.

Sometimes carbon dioxide, another indicator, is being given off by the work being heated and must not be used as a sole indicator of excess air. Testing units work on the absorption principle while oxygen recorders work on the principle of mixing the gas sample with a fuel and catalytically burning the mixture. The combination of the instruments mentioned above will provide good control of combustion conditions.

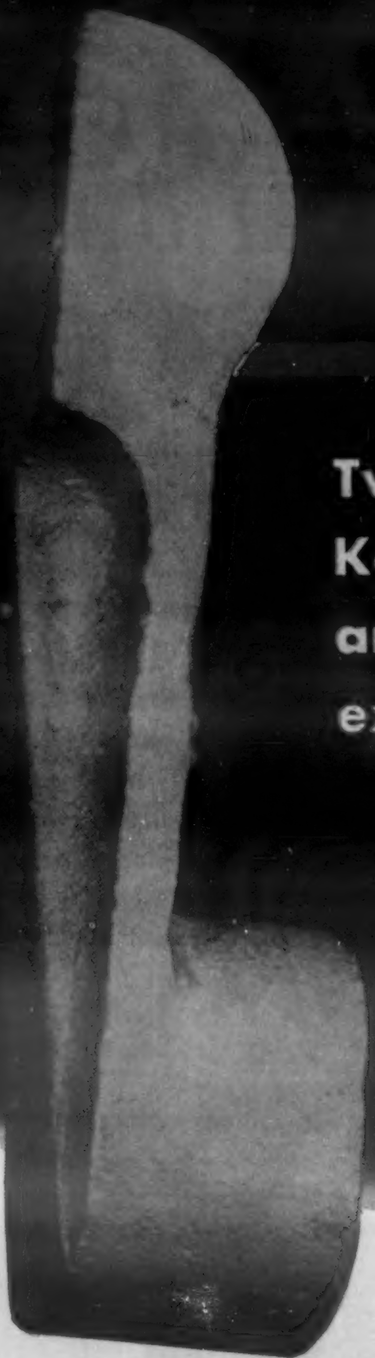
The dew point potentiometer and recorder is a new development for continuously determining and recording the dew point of furnace atmospheres. The mirror-type operates on the principle of determining the temperature at which a highly-polished mirror fogs, due to the precipitation of moisture from the atmosphere in contact with it. One of the newest is an electronic indicator which depends on the principle of ionization of water vapor to negative ions by electron bombardment. The degree of ionization of the atmosphere is taken as a measure of the amount of water vapor present.

A potentiometer-indicating type can determine dew points between 110 and minus 100 F. It can tell dew point of gases at high pressures and is entirely self-contained. The mirror is cooled until it fogs; then the temperature of the thermocouple, as determined by the potentiometer, gives the dew point.

Flow meters in steel plant applications often are controllers to maintain the proper relationships in the fluids they measure. One plant has 325 flow meters for different purposes. An instrument for indicating, recording and/or controlling furnace pressure is desirable. Future instruments for

Q:

A:



Which X-ray Film for examination of this multiple-thickness steel casting at 200 kilovolts?

Two films— Kodak No-Screen and Kodak Type A, exposed together.

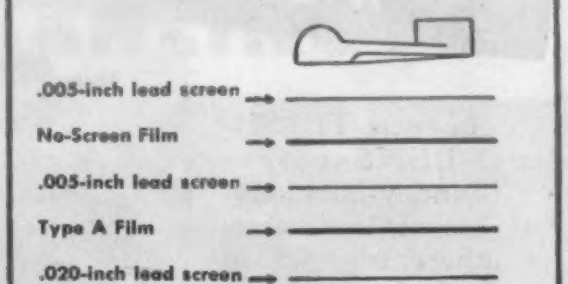
THE RADIOGRAPHER considered three possible methods of making his examination of this steel casting with its varying thicknesses.

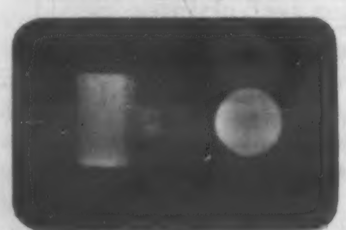
He could make two successive exposures, one for the thin section and one for the thick sections . . . and lose time.

He could use one film . . . but detail would not be satisfactory in all sections.

Or—and this is what he did—he could sandwich between three lead foil screens two Kodak Industrial X-ray films . . . No-Screen, a very fast film, to pick up irregularities in the thicker portion of the casting . . . and Type A, a slower film, to hold detail and show defects in the thinner section.

The technic he used is shown in the diagram at the right; the latitude, detail, and contrast he obtained with only *one* exposure are indicated by the two radiographs below.





No-Screen Film for detail in thick sections.

Type A Film for detail in thin section.

Kodak also offers these 3 important types of industrial x-ray film

Kodak Industrial X-ray Film, Type K . . . primarily meant for gamma and x-ray radiography of heavy steel parts, or of lighter parts at low x-ray voltages where high film speed is needed.

Kodak Industrial X-ray Film, Type F . . . with calcium tungstate screens—primarily for radiography of heavy steel parts. The fastest possible radiographic procedure.

Kodak Industrial X-ray Film, Type M . . . the first choice for use in critical inspection of light alloys or—with million-volt radiography—for examination of thin steel and heavy alloy parts.

Eastman Kodak Company
X-ray Division, Rochester 4, N. Y.

Kodak

this purpose will be diaphragm-operated.

To regulate gas-mixing, a heat-flow factor has been developed which correlates the Btu. content per cu. ft. and the gravity of the gases involved.

—*Industrial Heating*, Vol. 12, Dec. 1945, pp. 2082, 2084, 2086, 2088.

The Nivometer

Condensed from "The Engineers' Digest"

For measuring the level of a liquid in a vessel under pressure, the so-called "Nivometer" was developed several years ago by Brown Boveri for steam boilers, hot water accumulators and liquids under pressure. The transmission of the movement of the liquid requires no bushings or glands. It also avoids any kind of mechanism under pressure.

A U-shaped pressure tube of non-magnetic steel contains mercury. An iron ball floats on the surface of the mercury in one of the limbs. Through the ball the movement of the column of mercury is transmitted through the walls of the pressure tube to the measuring mechanism purely magnetically.

The two poles of a powerful, pivoted permanent magnet enclose the tube without touching it so that the magnet, because of the field of force, must follow the movement of the ball. By giving a suitable shape to the shoes of the poles of the magnet, an exact correspondence of the indicating mechanism with the position of the ball is ensured.

The position of the pivoted magnet, which corresponds to the level of the liquid, is indicated by a pointer on a large scale visible at considerable distance. The instrument also registers variations on a recording strip. Adjustable contacts can be added to operate signalling devices or perform control.

The Nivometer is connected to the pressure vessel by two pipes so that one of the limbs of the U-tube is in communication with the liquid below the lowest level while the other is connected to the vessel above the highest level by a tube in which there is a constant head of liquid.

A typical use is for compressed air loaded hydraulic accumulators for operating forging presses which work with pressures of 300 to 320 kg per sq. cm., where it is a water level indicator and controls a relay regulating the feed and the outlet of the accumulator.

The level of the contents of the accumulator is transmitted to signal lamps in the press workshop so that the staff can at all times satisfy themselves as to the state of charge of the accumulator and arrange the operating processes accordingly. In the lowest position the Nivometer stops the flow of water out of the accumulator until a certain minimum reserve of water is again present.

—A. Spoerli. *Brown Boveri Rev.*, Vol. 31, No. 8, pp. 270-273; as abstracted in *Engineers' Digest* (British), Vol. 6, Oct. 1945, p. 277.

engineering BOOKS

Atomic Power

URANIUM AND ATOMIC POWER. *By Jack DeMent & H. C. Dake. Published by Chemical Publishing Co., Inc., Brooklyn, N. Y., 1945. Fabrikoid, 5¾ x 8¾ in., 343 pages. Price $4.00.*

The title of this book is most misleading. No one interested in either the engineering aspects or the social significance of nuclear energy would buy the book if he had an opportunity to thumb its pages, and one gathers that there is a profitable market for books bought by librarians and others purely by title or from information in publishers' blurbs.

The book is *not* on uranium and atomic power. It does have an extensive list of uranium minerals and compounds, and discusses at length the detection and determination of uranium by various means, including fluorescence, which is obviously a hobby of the authors. Properly titled, it might have been found useful by a limited group of readers.

All the information on fission and other nuclear reactions is taken from pre-war sources and is far inferior in both content and style to the now famous, and cheaper, Smyth Report.

—CYRIL S. SMITH

Furnaces for Heating Steel

THE HEATING OF STEEL. *By M. H. Mawhinney. Published by Reinhold Publishing Corp., New York, N. Y., 1945. Cloth, 6¼ x 9¼ in., 265 pages. Price $4.75.*

In a sense, this is a new edition of the author's 1928 book on "Practical Industrial Furnace Design," but confined to the present title. Since 1928, major attention has shifted from mere conservation of fuel and uniformity of heating of the charge, though these remain important, to preservation of the steel surface against scaling and decarburization, by the use of controlled atmospheres or salt baths.

Chapter headings are: Chemical Effects of Heating Steel; Fuels and Burner Equipment; Temperature Distribution and Furnace Control; Heat Transfer and Fuel Economy; the Quenching of Steel; Alloys and Refractories; Steel Mill Furnaces. The treatment is primarily that of the mechanical engineer, interested in the mechanisms.

Where controlled atmospheres are to be used, electricity or gas burned in radiant tubes are considered the most suitable fuels. Relatively little attention is given by Mawhinney to salt baths or induction heating. Production of controlled atmospheres is usefully discussed, with suitable emphasis on selection of atmosphere to suit the steel for avoidance of decarburization.

Without going deeply into the metallurgy involved, the reasons for the utility of various mechanical designs for accomplishing various metallurgical results are sufficiently set forth.

It's a worthwhile book.

—H. W. GILLETT

Plastics

PLASTICS IN PRACTICE. *By John Sasso & M. A. Brown, Jr. Published by McGraw-Hill Book Co., Inc., New York, N. Y., 1945. Cloth, 7½ x 10¾ in., 185 pages. Price $4.00.*

Instead of writing a book about plastics containing chemical compositions of the various types, with tables of physical properties for each, the authors have produced a book composed of more than 100 condensed case histories of plastics applications. They have carefully limited the scope of the book in their preface by pointing out that it is not intended as a treatise for the plastics chemist, but as a guide for the user or potential user, or for men in the selling profession who must deal with the plastics industry.

The examples are so selected that they will cover the principal plastics types and methods of fabrication. In connection with each there is indicated the reason for choosing that particular material or process for manufacturing the given item.

If the reader will go through the entire book, studying each example given, he will discover that when he reaches the end he will have absorbed, quite painlessly, a substantial amount of information about plastics.

—KENNETH ROSE

Other New Books

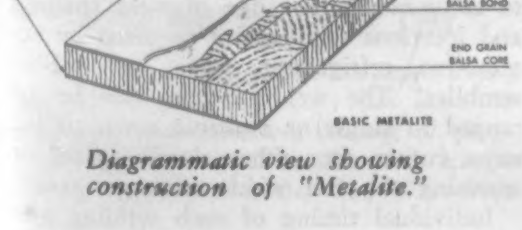
EXPERIMENTAL STRESS ANALYSIS. PROCEEDINGS OF THE SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS. VOL. II, No. 2. *Edited by C. Lipson, Chrysler Corp., & W. M. Murray, Massachusetts Institute of Technology. Published by Addison-Wesley Press, Inc., Cambridge, Mass., 1945. Cloth, 8¾ x 11¼ in., 166 pages. Price $5.00.* This book contains the papers presented at the fall meeting of the society held at Cleveland in 1944, and at the symposium on crankshaft stresses. The discussions following presentation of the papers are also included. Among the subjects covered are shot peening, various new instruments and gages, studies of residual stresses, of load distribution in riveted and spotwelded joints, and of plastic flow. The crankshaft stresses symposium includes their structural evolution, their fatigue testing, and their metallurgy and processing.

THE MACHINISTS' AND DRAFTSMEN'S HANDBOOK. *By A. M. Wagener & H. R. Arthur. Published by D. Van Nostrand Co., Inc., New York, 1945. Fabrikoid, 5⅝ x 8 in., 662 pages. Price $4.50.* A book of this nature, which would answer every purpose completely, would be so comprehensive as to be too large, expensive and unwieldy. So the authors have incorporated in this small volume all the basic information required in a great majority of the daily assignments of machinists and draftsmen. The material has been critically selected though some that might be considered useful and important has been omitted of necessity. Solutions of many elementary mathematical problems are included in considerable detail. The sections devoted to Strength of Materials, Mechanics, and Logarithms have been revised from Lobben's "Machinists' and Draftsmen's Handbook of 1899." This new volume will be found very useful to many.

New Lightweight Structural Material

A new structural material, basically a metal-faced sandwich material employing a light-weight core to separate and stabilize the metal faces, is announced by the *Chance Vought Aircraft Div.* of *United Aircraft Corp.*, Stratford, Conn.

The material, known as "Metalite," consists of thin sheets of high strength aluminum alloy, separated by a thick, low density core of balsa wood and bonded firmly together to form a single light, rigid unit. The grain direction of the balsa core is set perpendicular to the metal faces.



Diagrammatic view showing construction of "Metalite."

A core material of greater density than balsa can be used in spots where greater strength is desired. The core is relatively thick in comparison to the face plates.

The new material is constructed by bonding the core and faces together under moderate heat and pressure, all the bonds being ordinarily made in one operation. The bonding operation is done with the parts or assembly in a mold of the desired shape.

For flat work, the parts are normally put together on a bench and the whole assembly placed in a mold afterward. For curved work, both single and double, several different forming methods can be used. Where only gentle curves are required, the work can be assembled flat on a bench and the entire assembly placed in a mold and forced into the desired shape by the application of pressure.

Vacuum Unit for Industrial Applications

A universal vacuum unit for use in the fields of research, development and processing is announced by the *Engineering Products Div., Radio Corp. of America,* Camden, N. J. The unit, originally developed for the preparation of specimens for the electron microscope, is adaptable to vacuum coating of materials up to 13 in. in diam. and 24 in. high.

Mirror surfaces, non-reflecting surfaces, or any special coating may be evaporated and condensed on metals or non-metals. Metals may also be sputtered onto surfaces. In addition, the "EMV-1" unit may be used for vacuum drying or freeze drying.

Provision is made to admit gases into the bell jar after the air is removed, so that many types of experiments may be conducted in various atmospheres at varied pressures.

● A new safety device is announced to eliminate the need of goggles and face shields in many machine tool operations. Known as the Magnetic Grip-Shield, it consists of thick transparent sheets of plastic anchored into a horseshoe permanent magnet. Made in various sizes, it may be instantly positioned without tools. The magnet holds it in position, yet with a slight twist, may be moved to suit conditions. It deflects flying chips, metal dust, sparks, oil and liquids to protect operators without obstructing vision. It is used on all types of machinery where protection is needed. Sizes range from 3 in. by 4 in. to 8 in. by 10 in., and also comes in hood type for long time operations. It is made by the *Dilley Mfg. Co.,* 10150 Euclid Ave., Cleveland 6.

Metal Sorting Instrument

A new instrument, developed by the *Control Equipment Co.,* Pittsburgh 21, identifies and sorts pure metals, steels and nonferrous alloys. The "Metalsorter," Type B, is portable, requires no special electrical power supply, and makes nondestructive tests on finished products.

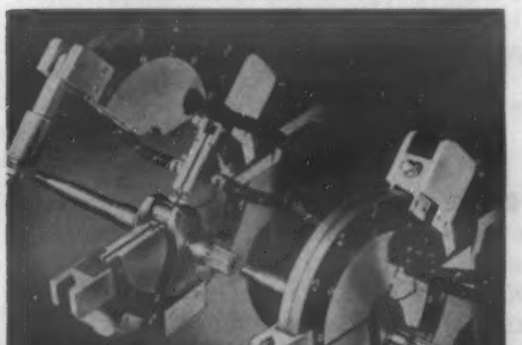
The unit employs the tribo-electric effect. A metallic specimen of standard, known or acceptable character is rubbed against the surface of an unknown or doubtful piece. If a chemical or metallurgical dissimilarity of the two pieces exists, a minute electrical current is generated and is registered by an indicator on a calibrated scale. When there is no dissimilarity, no electrical current is indicated.

Since the test is nondestructive, it may be applied to the identification of built-up machinery and aircraft assemblies and structures. The fact that the pieces being tested are in metallic and electrical contact with adjoining members does not effect the accuracy of the test. Electrical connection to the pieces is automatically and simultaneously made with each test.

Split-Coil for Induction Hardening

A specially designed split-type coil has been developed by the *Induction Heating Corp.,* New York 3, for the induction hardening of localized surfaces of such parts as crankshafts, camshafts, and similar components.

The "Thermonic Multi-Turn Split Coil" consists of two or more turns made up of machined copper plates, which are split and hinged in such a manner as to allow the coil to be opened, the work inserted in place, and the coil closed and clamped, automatically making contact between the segmental sections. The segments of the coil are held in relationship to each other by an insulating retainer ring which runs around the outside of the coil proper and forms a closed passage between the coil turns.



The split-coil induction heater with parts in place for heating.

With this split-coil power concentrations as high as 20 kilowatts per sq. in. on ½-in. diam. shafts are possible, resulting in hardened cases of 0.020-in. thicknesses when used with equipment having an output frequency of 375,000 cycles.

Hydraulic Bending and Forming Press

A newly designed hydraulic press for bending and forming steel parts is announced by *Lake Erie Engineering Corp.,* Buffalo.

The press is a 200-ton "C" frame type with a 42-in. right to left and 24-in. front to back die space. It has a 30-in. daylight opening and 16-in. stroke. The press has a closing speed of 350 in. per min., and a return speed of 345 in. per min.

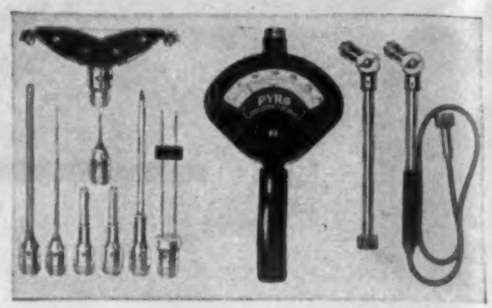
The upper or moving platen is rigidly guided; a 35-ton cushion is in the bed. The press is operated by a hand lever, and control of operating speed is obtained by direct stroking of the pump.

The press being installed in the McCormick Works of the International Harvester Co., Chicago.

● Improved cast iron thermocouple protecting tubes for the chemical, metallurgical and die casting industries have been introduced by the *Brown Instrument Co.,* Philadelphia, industrial instrument division of Minneapolis- Honeywell Regulator Co. The new tubes have a uniform wall thickness to within plus or minus 1/32 in., and have better surface finishes. They are cast with both ends open, permitting positive support for the core at each end. One end is closed with a cast iron plug, welded in place with a cast iron filler rod, the opposite end being threaded for a 1-in. standard pipe. Available at lower prices than previous types, they have an inside diameter of 13/16 in.; outside of 1⅜ in.; wall thickness of 9/32 in.; a minimum top thickness of 9/32 in., and weighs 4.5 lb.

Surface Pyrometer

The development of a new surface pyrometer designed for the plastics industry as well as the metals field is announced by The *Pyrometer Instrument Co.,* 93 Lafayette St., New York 13. The instrument is equipped with an internal automatic cold end compensator so that external surrounding temperatures have no effect on the true temperature reading of the pyrometer.



The surface pyrometer with various types of interchangeable thermocouples and extension arms.

The pyrometer is self-contained and portable, and has a 4-in. direct reading scale on a 4¾-in. indicator. Eight different types of interchangeable thermocouples, which can be used without a recalibration or adjustment of the instrument, makes the pyrometer adaptable to many metallic and non-metallic surface temperature problems.

Control Unit for Resistant Welders

A new resistance welder control unit, designed and built by *Progressive Welder Co.,* 3050 E. Outer Drive, Detroit 12, Mich., permits automatic assembly welding rates up to 900 spots per min.

The "Ultra-Speed" unit is the heart of all new Progressive welding machines. It distributes welding current to a single or to groups of welding points successively by means of a screw driven carriage that depresses push rods to engage contacts much in the same manner as one would run a finger over a piano keyboard. At the same time, another element of the carriage engages adjustable stroke plungers to control individually the length of time the welding current flows for each weld.

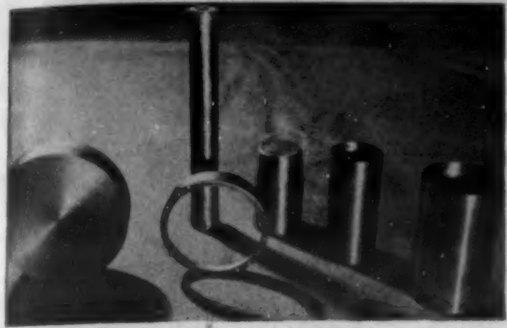
All welding points bear on the work simultaneously under welding pressure before the first weld is formed and remain until the last weld is completed, eliminating the separate "squeeze" and "hold" times usually required for each weld.

These controlled machines can be built to accommodate a range of weld spacings and locations such as are required by automotive, refrigerator, stove, etc., sub-assemblies. The welding guns can be arranged in single or multiple rows, circles, steps, curves, etc., either closely spaced or spanning the full width of large panels.

Individual timing of each welding gun permits the spot welding of different thicknesses of metals during one complete operation. Thus, reinforcing sections, brackets, spacers and trim forms can be joined to a main panel using the most suitable type and thickness of metal for each.

Molybdenum Made into Versatile Shapes

Limitations on the production of molybdenum in "chunks" of large size and multiplicity of shapes have been removed by *Westinghouse Electric Corp.* engineers, and the cost has been reduced to one-third. This has been done in the company's Bloomfield, N. J., plant devoted to the manufacture of lamps and electronic tubes.



Some complicated shapes of "Moly" powder now possible.

The very qualities of "moly" that have seemed so long attractive to designers have been the very ones to block its production in large sizes and complex shapes. Moly melts at 4748 F (iron, 2800; copper, 1976). Thus, although pure "moly" in powder form can readily be prepared from its natural oxide, it cannot be melted like other metals to form large solid pieces, because any container or crucible of known materials would melt first.

Thus, in the past molybdenum pieces have been made by compacting "moly" powder into the desired shape under great pressure, and then passing a high current through the piece to bring its temperature up just below the melting point, so that the particles rigidly adhere to each other. This method has obvious limitations, both as to sizes and shapes.

Now the piece can have any desired shape that can be molded. It can be round, square, with fins, or angles, or holes and with much larger overall dimensions than heretofore possible. "Moly" is now proving valuable in the form of crucibles, electronic tube parts, electrical contacts, electrodes for resistance heating of glass welding tips, thermocouple tubes, and for electric furnace heating elements for high temperature work in a vacuum or protective atmosphere. It is expected to be useful for welding alloys and high-temperature engine parts.

Plastic Coating Melting Tank

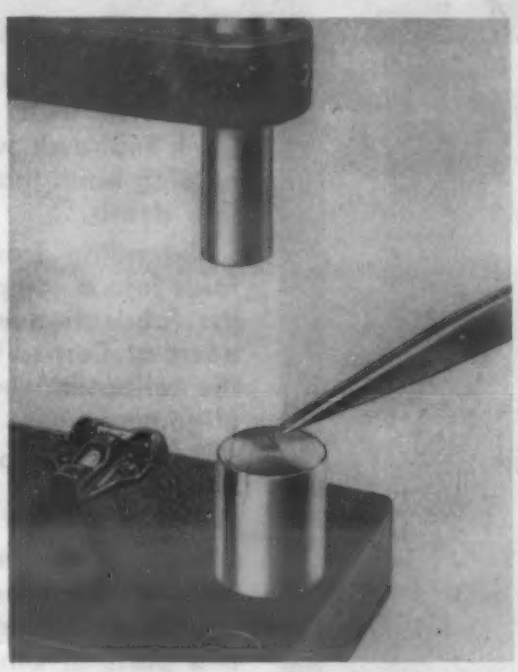
A new portable, plastic coating melting tank of one-gallon capacity has been designed for the protective coating of plugs, gages, carbide tipped tools, and similar items by *Aeroil Products Co.*, West New York, N. J.

The equipment, called "Midget-6," has a one-piece inner vat of heavy, warp-proof cast aluminum of high heat conductivity. Other features include thermostatic controls to automatically maintain heat at required temperature, a removable cover with insulated plastic knob handle, a neon pilot light for visual check, and a carrying handle for ease in portability. The complete unit weighs 16½ lb.

Magnetic Hardness Tester

A new magnetic hardness tester for rapid, accurate gaging of hardness of small, ferrous metal parts has been announced by *General Electric Co.'s Meter & Instrument Div.*, West Lynn, Mass. Providing a convenient "go—no go" hardness gage, this tester simplifies inspection of such parts as electric instrument pivots and shafts, watch shafts, small steel balls, and other parts too small to be production-tested with mechanical-type hardness testers. It also permits spot checking of hardness in large sheets, or lengths of steel wire, through the comparison of random-selected small samples.

The tester, 6 in. long, 3½ in. wide, and 7 in. high, consists of an Alnico bar magnet set in an adjustable, soft-iron frame, which permits the air gap, and thereby the field strength, to be set at the correct value for testing pieces of different size, whose dimensions are between 1/16 and ½ in.



Hardness testing of tiny metal parts with this equipment is possible.

A knurled thumbscrew locks the air gap adjustment, and a brass block for positioning the specimens is mounted on the base of the tester, a little out of the direct line of the magnetic field. A two-way level is attached to the base to show when the tester is properly positioned, and a pair of brass tweezers is furnished for handling the specimens.

Operation is based on the correlation of hardness and coercive force in magnetic materials. It checks pieces of unknown hardness against a specimen of known hardness by comparing, in a simple, mechanical test, the relative strength of the magnetism produced in the test pieces and in the standard specimen, under the same conditions of magnetization. This test will distinguish differences as little as 2 points on the Rockwell C scale, and does not damage the piece tested.

Deep-Throat Spot Welder

A spot welding machine primarily intended for welding deep sheet metal of light gage has been made available by the *Eisler Engineering Co.*, Newark 3, N. J. In addition, the unit can be used with a hand operated push type and long type gun welder, and for a.c. arc welding (100 to 400 amp.).

The deep throat of the machine is provided by both horns which can be lengthened or shortened by sliding them in the bearings to fit the size and type of sheet metal work to be welded. The horns are mounted on the top of the fabricated case, and makes the machine suitable for spot welding large sheet metal parts.

● A new material designed for plastics reinforcement has been developed by *Owens-Corning Fiberglas Corp.*, Toledo, Ohio. The mat is composed of continuous glass filaments bonded with a vinyl resin and may be softened either by heat or by solvents in the usual contact-pressure resins. This property makes it possible for the fabricator of formed parts in which the mat is the reinforcing material to form the mats by applying heat alone, or by impregnating the mat with the resin that is being used.

Files and Hones for Carbide

A new line of diamond files and hones for dressing carbide cutting tools without removing them from the machine is announced by the *Wendt-Sonis Co.*, Hannibal, Mo.

Called "Diamond R," they contain a 100-concentration of diamonds in a new and exclusive metal bond that enables both to maintain a flat surface throughout their service life. Tools sharpened do not become "grooved." They can be used on high-speed steels without loosening the diamond particles.

The file shanks are of drill rod stock. Each comes in a handy leather case complete with instruction card. The hone is mounted on a lucite base. The files measure 6 in. long, ¼ in. wide, and 3/16 in. thick.

The hone and file contain a 100-concentration of diamonds.

They are available in 240, 320, 400 and 600 grit. The hone measures 3 in. long, ¾ in. wide and ½ in. thick. It comes in 400 grit only.

Metal Cleaning Aids

The development of a new concentrated emulsifying degreasant, known as "G-BEX 45-A," has been announced by the *Gaybex Corp.*, Nutley, N. J. An unusual characteristic claimed for this compound is that it gains in strength with dilution. It has a fresh, clean odor, is chemically neutral, and despite its powerful detergent action, it will not corrode metals or harm the skin.

The compound is recommended by the manufacturer for the cleaning and degreasing of floors, machinery, motors, equipment and parts that are being processed—prior to finishing or assembling. It may be applied with a brush or spray gun or by dip. It may also be used in standard emulsion degreasing tanks, either cold or heated.

When the dirt, oil and grease are thoroughly saturated, they are removed simply by flushing or hosing with water. A trace of the residual compound minimizes rusting after the washing process.

The same company has also recently introduced an emulsifying degreasing compound named "G-BEX C," which brightens as it cleans. Although it may be used safely on ferrous metals and many plastics, its qualities are especially blended to handle the degreasing and brightening of aluminum and white metal alloys.

Parts and surfaces may be dipped in or sprayed with this compound, then thoroughly rinsed with clear water. The action of the compound is to dissolve grease and oil, loosen dirt and reduce oxide stains. No powder or harmful residue remains after the water rinse.

A series of safety solvents to be called "G-SOL" has also been announced. The first of the series is intended for the cleaning of precision bearings, instrument parts, typewriters and similar mechanisms where both grease and oil gums are troublesome.

Test of Electrolytic Manganese

Seeking ways to make the United States less dependent upon foreign sources of manganese, the *Bureau of Mines* recently completed successful cooperative tests with industry on the use of electrolytic manganese from low-grade domestic ores in the manufacture of acid steel.

When electrolytic manganese produced in a Bureau pilot plant at Boulder City, Nev., was substituted for the usual imported ferromanganese in full-scale commercial heats of steel at the cooperating plants, the Atlas Steel Casting Co., Buffalo, N. Y., and the Detroit Steel Casting Co., Detroit, it proved entirely satisfactory and the carbon steels obtained had slightly better physical properties.

In both plants, efficiencies attained with electrolytic manganese additions were at least as high as those normally attained with ferromanganese, and the substitution was entirely satisfactory in the grades of steel tested. Although the quality of the steels compared very closely regardless of the form of manganese used, there was a trend toward better quality with electrolytic manganese.

High-Speed X-Ray Unit

Featuring peacetime uses of the millionth-of-a-second Micronex — the phenomenally high-speed X-ray unit which enabled ordnance experts to "stop" projectiles in gun barrels for wartime study, and made important still-secret contributions to atomic bomb development—the *Westinghouse X-Ray Div.*, Baltimore, recently demonstrated X-ray equipment available for post-war industry and medicine.

Perfected under the stresses of war to make possible detailed studies of the protective characteristics of armor plate and the behavior of armor-piercing shells, this unit was used later in atomic bomb development.

Operating on the surge generator principle, the unit builds up great reserves of power, which are loosed in one instantaneous burst to activate a special tube which generates X-rays capable of penetrating 1 in. of solid steel in one-millionth of a sec.

Widely used in arsenals and laboratories for war work, the Micronex shows great peacetime possibilities. Tests already under way indicate its great value in failure tests of materials. In testing a bar of steel to destruction, one instant it retains its form, then, within a fraction of a second, breakage occurs. With the Micronex, one can make a photograph at the exact instant of failure and thus observe the phenomenon.

Other possibilities include studies of: cutting tools operating at high speeds; shaft action within a bearing; life and behavior of cutting oils; metal stresses under forming, spinning or forging operations; etc.

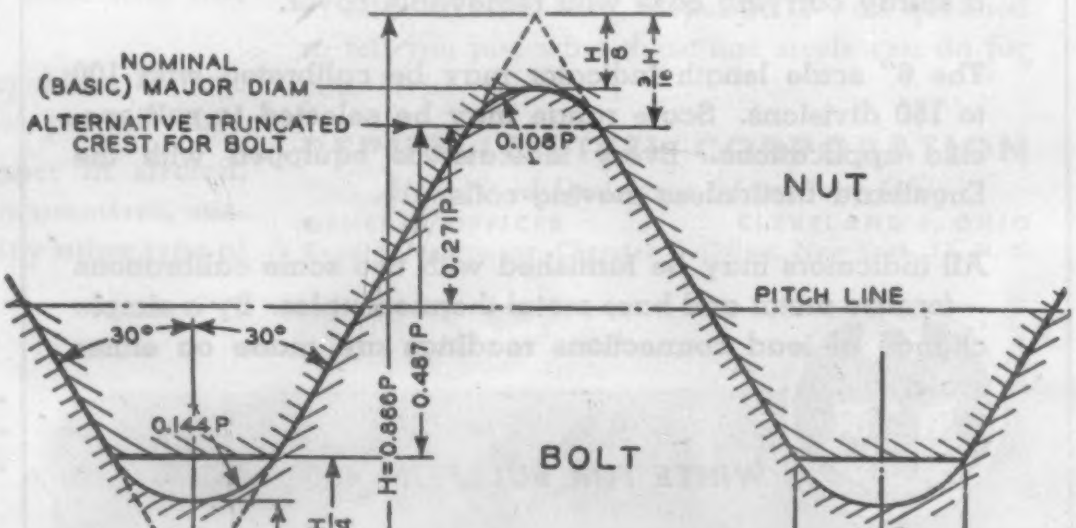
Other industrial equipment on display includes: three heavy stationary units for examining large castings, forgings, welds, etc.; one mobile unit for the same work; the Productograph, a completely enclosed cabinet unit for production line inspections —much like the special war-developed unit for high-speed inspection of rocket powder charges; and two units with tubes mounted on heavy jib cranes for positioning to accommodate work of unusual size or shape.

New Basic Screw Thread Form

The Standards Associations of the United States, Canada and Great Britain have agreed on the unification of screw thread standards in the industries of the three countries. The drawing shows the proposed new unified basic form of the thread. It has an angle of 60 deg. and a rounded crest and root.

The radius of the root of the screw is larger than the radius of its crest. Truncation of the crest of the screw is permissible. Threaded products made to this new form will be practically interchangeable with those having the same nominal diam. and pitch made to the present American standard.

This proposed form recommended as a standard is the result of efforts to retain the best features of the present forms. At the same time a series of associated diameters and pitches have been worked out which it is believed will simplify existing practice and yet provide an adequate range of choice for all general requirements. The proposed change will involve a minimum departure from existing practice consistent with obtaining a common standard for general purpose threads.



The new basic screw thread form which will be adopted by United States, Canada and England.

New Diesel-Driven Welder

A new diesel engine driven welder of 300-amp. capacity specially made for use in locations where electric power is not available, or not economical, is announced by the *Lincoln Electric Co.*, Cleveland. Powered by a two-cycle diesel engine, this welder is said to cut fuel costs up to 86%, depending upon the price of fuel oil used.

Equipped with dual continuous control, the welding unit permits the operator to select any type of arc and any arc intensity to suit the job. This feature improves the speed, quality, and ease of welding. Also, because of its fine adjustment, it makes possible a much wider range of application—both as to thickness and classes of metals and alloys. Other features of the welding generator include separate excitation and laminated magnetic circuit for a smoother, more productive arc at all current values.

The welding generator has N.E.M.A. rating, 300 amp. at 40 volts. Current range for welding duty is from 20 to 40 volts, 60 to 375 amp. The patented dual control of welding current is accomplished by adjustment of both series and shunt fields. It supplies uniform welding current for metallic arc welding in any position with bare or heavily coated electrodes, also for carbon arc welding.

The unit weighs 2,560 lb. and can be readily mounted on wheels, trailer or truck for easy portability.

● A new instrument for recording machine running-time has been developed by the *Bristol Co.*, Waterbury 91, Conn., for checking machine performance. The instrument records the operating or "on" time of production machinery and other similar equipment. The chart record gives the total "on" time in hours, minutes, and seconds for a given period. "Off" periods are also shown on the chart, as well as the time at which they occurred. The running-time readings are magnified in such a way that the total operating time of a machine can be easily and accurately determined to within a few seconds.

Prehardened Die Steel

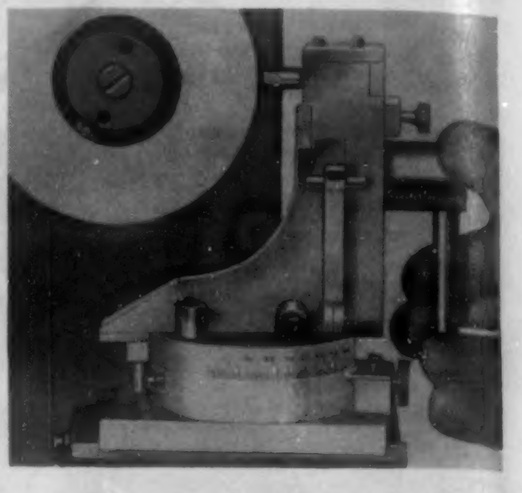
To provide die casters of zinc and zinc-lead alloys with a prehardened die steel of service life and machinability, *Heppenstall Co.*, Pittsburgh, has announced the availability of a new die steel, "Silver Hardtem."

This die steel is being produced in the form of die blocks, as well as die block bars and inserts, and can be furnished at any desired hardness. However, the usual hardness required for zinc and zinc-lead alloys is between 286 and 321 Brinell hardness.

Die made of "Silver Hardtem" are reported not to load or mutilate at the parting line. The necessity for frequent removal from casting machines for surface repair is also said to have been minimized.

Radii and Angle Dresser

Form-dressing on cylindrical, internal and small bench-surface grinders has always presented problems. The *J & S Tool Co.*, 477 Main St., East Orange, N. J., has built a



This form dressing machine has a variety of uses.

new design radii and angle dresser, model "F," which is well adapted for cylindrical grinders with spindle heights as low as 5 in. from the base of the table and accommodates wheel diameters up to 7 in.

Its compact size is suited to internal grinders with wheel diameters under 7 in.

● *Beatty Machine & Mfg. Co.*, of Hammond, Ind., announce a new 25-ton hydraulic tube testing press. This new unit is designed for testing tubes up to 3¼-in. i.d. and 48 in. long at 4800 lb. per sq. in., hydrostatic internal pressure, but within limitations of its pressing and space capacities can be used for other diameters and lengths with the proper ram attachments.

Top Fired Crucible Melting Furnace

A new top fired crucible melting furnace, using two crucibles (fired with gas or oil) in tandem, is offered by *Radiant Combustion, Inc.*, of Warren, Ohio. This new furnace holds two crucibles, loaded at all times and alternately fired.

While the gas or oil flames are heating the first crucible, all of the flue gases produced are carried by a connecting flue to the second chamber to preheat the second crucible. During the pouring of the metal from the first or fired crucible, a third crucible replaces the removed crucible to receive cold metal.

Among the advantages claimed from this new furnace, by the manufacturer, are faster heating through combined radiant and convection heating; burners cannot plug because they are in the top where slag or metal cannot reach them; and far lower metal loss obtained as the flame does not impinge on the metal.

The metal is visible at all times, and temperatures can be taken whenever desired without shutting off the burners.

TAKE a good look at that picture above. It's front-page news!

All of those so-different materials are perfectly bonded by *one* agent.

That revolutionary, new, quick-setting plastic adhesive is *Pliobond* . . . developed by American industry for solving wartime production problems. Pliobond firmly joins any materials . . . like or unlike . . . metals, plastics, fabrics, glass, rubber, wood, paper, plaster, leather, concrete, etc.

With Pliobond most applications need no high pressure or heat. For exceptionally high shear strength, moderate pressure and 200-300°F. are sufficient.

Other important characteristics of this remarkable new adhesive: It's strong . . . permanent . . . withstands constant flexing . . . sets quickly . . . is immune to fungi . . . resists water, oils and wax.

Pliobond is always ready for instant use. Because it is a *one*-part bonding agent, there are no fussy mixtures . . . no exact weighing. It can be brushed, sprayed, spread or roller coated.

Don't these amazing features give you ideas toward solving production problems? For technical information, please use coupon, writing us in detail on any special problems.

UNITED STATES PLYWOOD CORPORATION *EXCLUSIVE DISTRIBUTORS*

Industrial Adhesives Division:

55 West 44th Street, New York . . . Branches in Principal Cities

*PLIOBOND** *is a product of* **THE GOODYEAR TIRE & RUBBER COMPANY**

*Trademark registered, The Goodyear Tire & Rubber Company

Pliobond
. . . BONDS ANYTHING TO ANYTHING

UNITED STATES PLYWOOD CORPORATION,
55 West 44th Street, New York 18, N. Y.

Please send me descriptive literature on PLIOBOND.

Name ______________________ Title __________

Firm ______________________________________

Address ____________________________________

M. & M. 4-46

Portable Thread Gage

The *Bryant Chucking Grinder Co.* of Springfield, Vt. has developed a portable thread gage that provides for inspection of internal threads in parts where bench inspection is inconvenient or while parts are still in the machine.

The new Bryant portable thread gage has three thread segments. Two are stationary and one is attached to a movable arm. By pressing the operating lever, the movable segment is retracted, forming a pilot which can be inserted into the work without thread interference.

Releasing the operating lever engages the segments with all the internal threads, a partial turn of the gage inspecting the threads all over. At the same time overall accuracy, or accumulated inaccuracies of lead, pitch diameter and thread form or presence of burrs, are indicated.

Because only a partial turn is needed, the segments have a long life and no taper occurs, as on conventional plug gages. Inspection of different sized threads is accomplished by changing the segments.

● *Manning, Maxwell & Moore* of Bridgeport, Conn., announced the development of a new bellow type low range pressure gage suitable for indicating draft pressures or any low pressures of gases or liquids that are not corrosive to bronze. The pressure element is a self draining bronze bellows with a phosphor bronze calibration spring which makes an extremely sensitive and accurate gage. Adjustable stops protect the bellows from excess pressure of vacuum.

Color Rustproofing

A chemical immersion process, imparting color to "Parkerized" iron and steel surfaces, and greatly increasing corrosion resistance of the coating, is announced by *Parker Rust Proof Co.*, Detroit.

Color "Parkerizing" is a complex phosphate coating, integral with the metal surface, completely insoluble in water, which does not smudge, chip or peel and effectively retards the spread of corrosion from abraded areas. It is available, in gray, blue, purple, green, and olive drab.

Only simple additional equipment, in addition to the Parkerizing process, is needed and practically no extra labor is involved. The same drums or baskets used for Parkerizing can be carried through the color treatment tank for the 2- to 6-min. immersion.

Complicated shapes and parts with threaded members and holes are coated equally as well as flat surfaces. The color coating results from chemical reaction, is uniform, without drips or tears.

The color finish has great value for assembly identification where parts of similar appearance may have different tensions, threading, fractional differences in length or head sizes or made from varying alloys. Quick identification by color is especially useful in valves, sprinkler systems and all assemblies using right and left hand threads.

Induction Heater for Production Soldering

An induction heater has been developed by the *Marion Electrical Instrument Co.,* Manchester, N. H., to meet the need for clean soldering of metal to metallized glass and ceramics. The equipment, originally designed for the production of glass-to-metal hermetically sealed electrical indicating instruments, is now available for use by manufacturers in various branches of industry wherever small parts or assemblies need soldering.

The equipment is applicable in the electronic industry as well as in other lines, including jewelry, toys, instruments, automobile parts, electrical fixture components, household fixtures, and any manufacturing application involving small part assemblies.

When soldering by torch, solder generally runs over the sides of the pieces, requiring sanding and filing operations to clean the piece preparatory to plating. However, when soldering with the induction unit, solder is restricted to the work area, and the additional cleaning operations have been eliminated. Another advantage is that it is possible to accurately jig-locate parts of the assembly and avoid subsequent machine operations—an additional saving.

Although the working efficiency will vary some, depending upon the materials being heated, the circuit has been designed to provide maximum conversion of the 60-cycle power into heat. Efficiency is greatest when the work to be heated has a high resistivity, as in the case of ferromagnetic materials. In the case of low resistivity materials, such as copper and silver, efficiencies are, of necessity, somewhat lower, which means that the smaller percentage of total power is converted to useful heat.

Universal Testing Machine

A machine for making tensile, traverse and compression tests up to 60,000 lb., hydraulically operated, is announced by *Steel City Testing Laboratory,* 8843 Livernois Ave., Detroit 4. The piston and cylinder of this universal testing machine are a lapped finish, carefully fitted without any packing, allowing for a minimum of friction.

The pulling head unit thrust is taken on a large steel ball and socket, which allows the head to float. The upper and lower pulling heads are of the conventional type with wedge type jaws for both flat and round specimens. Holders are also available for shoulder and thread end specimens.

A suitable load regulating valve is provided that will maintain a uniform load rating. Any load can be held for any period at the will of the operator. The gages are provided with maximum pointers, both gages are fully protected against overload, and gage selector valve is provided . . . a maximum stroke of 6 in. is provided in the cylinder. The traverse table has a maximum span of 30 in.

Riveter for Fragile Materials

A spinner-riveter especially adaptable for use in assembly work on non-metallic materials such as plastics and fiber is announced by the *Plymouth Engineering Co.*, Plymouth, Ind.

This new unit utilizes a relatively narrow faced tool, which contacts only a fraction of the rivet at each blow. The tool is rotated while a pneumatic hammer strikes a series of rapid blows. Rotation of the tool spreads the peening over the entire surface of the rivet head. This rotating movement adjusts the force of the blows within that stress which the rivet body itself will withstand.

Pressure is confined to the rivet itself, not on the parts being assembled.

● By electroplating chromium on a copper backing, *General Electric X-Ray Corp.*, Chicago, Ill., has developed a chromium-target X-ray diffraction tube with a rating as high as that of copper-target tubes. The old-type chromium-target tube was rated at one-fourth the heat input possible with copper, while the new model makes chromium competitive with pure copper in efficiency. Use of the new type is indicated in experiments requiring the high resolution provided by chromium, with its characteristic longer wavelength radiation.

Machine to Study Rotating Objects

General Electric Co. engineers with the aid of a newly-developed instrument, the "Rotascope," now are able to make any rotating object appear motionless before their eyes. The blade of an electric fan, or an airplane propeller, will appear to stand still, even though they're whirling at full speed, when the "optical engineer" is focused upon them.

Developed for the study of airplane propellers under actual operating conditions, this is the first instrument of its kind which allows the continuous viewing of a rotating object at any point on the perimeter (or path of travel). It is an answer to the scientific problem for an optical system capable of untwisting the light of rotating equipment before it is recorded by the human eye.

It eliminates the rotary component of motion, but shows any flutter or vibration of the moving part, thereby making it possible for engineers to make a thorough study of the rotating parts of machinery. One can actually see what happens to any of the rotating objects while under the "strain" of thousands of revolutions per min.

Lowest speeds as well as speeds up to 2000 r.p.m. can be studied. Special designs of the instrument can be made for the study of higher speeds. The "optical engineer" also may be used in industry for the study of angular motions, particularly those of low angular velocities.

High-Speed Perforating Press

A new design of perforating press is available from the *E. W. Bliss Co.*, Toledo, Ohio. The press has 75 tons capacity, and was designed for fine perforating operations requiring precision dies and extreme accuracy in the feeding mechanism.

A solid frame design with a great mass of metal especially in the bed and crown is used to properly dampen the vibration waves of constant frequency sometimes caused by continuous operation at fast constant speed. The crown is of semi-tubular section for rigidity.

The slide is very heavy, and is guided in precision bronze ways. Connections are of the solid steel ball type with adjustable ball seat constantly submerged in oil. The slide and connections are fully counter-balanced by heavy enclosed coil springs.

This 75 ton perforating press is designed for high speed work

The press is designed to accommodate sub-press die sets which are easily installed by sliding the die sets on the top of the bolster from the left hand side through an opening in the housing. The die sets are fastened to the slide and bed by bolts.

Automatic Electric Immersion Heater

The *American Instrument Co.*, Silver Spring, Md., announces a new automatic electric safety immersion heater for liquids. This heater and its automatic control, combined in one self-contained unit, can be installed in industrial water tanks, drums, processing kettles, stills, sterilizers, crank cases, pipe lines, glue pots, etc.

The heater can be screwed into the walls of a tank, drum, etc. through a 1-in. pipe fitting or reducer. Two or more of these automatic heaters may be installed on one application and adjusted for step temperature control, or, where it is desirable to install more than one heater in the same vessel, the heater can be used to regulate one or more non-automatic heaters through a relay.

It can be set at any temperature from room temperature to 350 F.

Air-Hardening Die Steel

The addition of a new tool steel to its line of specialized tool, alloy and stainless steels is announced by the *Carpenter Steel Co.*, Reading, Pa. The steel is an air-hardening, nondeforming die steel which combines the deep-hardening characteristics of air-hardening steel with the low temperature heat treatment possible with oil-hardening steels.

Named "Vega," this new steel hardens entirely through in large sections by cooling from 1550 F in a free circulation of air. In an 8-in. diam., "Vega" has a hardness value from surface to center of Rockwell 60 C and at the same time maintains a fine-grained tough fracture. In smaller sections its hardness values are slightly higher.

Tests showed that the hardenability of manganese-chromium-molybdenum airhardening steels is greatly influenced by the carbon content and that hardenability decreases when carbon content exceeds about 0.70%. Experiments were continued until the proper proportion of other alloys which would give desired toughness with maximum hardenability was found.

The steel, because it can be heat treated from a temperature 200 F lower than 5% chromium air-hardening steels, does not require special high temperature furnaces. This lower hardening temperature also reduces the tendency to scale and holds dimensional changes to an absolute minimum.

When properly heat treated, Vega may be expected to expand only 0.0005 in. per in. of length, and upon drawing at 400 F will return to within 0.00025 in. of its original size. The steel has no special tendency to decarburize and, because it contains relatively small percentages of hard-to-machine alloys, is one of the easiest air-hardening steels to machine.

● A new industrial washing machine has been developed by the *Industrial Washing Machine Corp.* of New Brunswick, N. J. This new cabinet-contained model, designated as "RBM," is applicable to a variety of metal washing purposes and washes and rinses assorted parts, gears, tools, etc., up to 36 in. in diam. and 30 in. high.

Die Casting Machine

The *Cleveland Automatic Machine Co.*, Cleveland, announces a new die casting machine, designated as "Model 400," available for zinc, tin, lead casting or for magnesium, aluminum, bronze or brass.

A double-compartment furnace, on the zinc, tin-lead machine, with separate automatic burners for each compartment, does away with cold metal in the shot compartment. New metal is placed in the second compartment, automatically causing the overflow of readied molten metal into the shot section. Even temperature and uniform condition of the shot metal are maintained by this method.

New Lightweight Construction Material

Development of a new high-strength, lightweight construction material has been announced jointly by the *Glenn L. Martin Co.*, Baltimore, and the *United States Plywood Corp.*, New York.

The newly-developed material is made up of a core of lightweight material sandwiched between and firmly bonded to thin sheets of aluminum, stainless steel, wood veneer or plastic. The core, which is honeycombed, may be made of phenolic resin impregnated paper, cotton cloth, fiberglass, or linen, depending on the stress or weight the finished product will be required to carry. The development of a practical manufacturing method of bonding the metal or veneer sheets to the honeycomb core made the product possible.

The material is primarily intended for use in reducing weight without sacrificing strength in the transportation field. Thickness of the core may be from 1/8-in. upward and may weigh as little as 4 lb. per cu. ft.

Walls, ceilings and partitions in railroad passenger and freight cars are believed to be one of the most fertile fields for the new material. The use of the material for automobile bodies and for doors, frames and wall panels in home construction is also being explored.

● Further advance in the rectifier field, involving stabilized equipment with low voltage high current output is announced by *Green Electric Co.*, 130 Cedar St., New York. The unit is rated at 200 amp., voltage range zero to 3 v. Any voltage selected in range is maintained to within 50 millivolts over load variation from zero to 200 amp., and with line voltage variation of plus or minus 10%. The voltage stabilization system includes a motor-driven Powerstat and simple electronic pilot device. The principle is widely applicable to larger or smaller rectifier units.

Silicone Varnish for Electrical Equipment

A new silicone varnish that is heat stable and waterproof for use in impregnating electrical equipment is announced by *Dow Corning Corp.*, P. O. Box 592, Midland, Mich. Because of its low curing temperature (300 F), this "DC 996" Silicone enables all types of electrical shops to use this type of insulation.

Among its advantages are: Greater protection against failure due to sustained overloads; greatly increased service life of insulation; higher permissible operating and ambient temperatures; increased protection against excessive moisture; elimination of fire hazards; and increased power output per unit weight.

Electrical equipment can be baked fully assembled without damaging the commutators or slip rings. The curing temperature does not affect shellac-bonded mica or core plating.

Dial Indicator Micrometer

A new type of micrometer, which has the additional advantage of a dial indicator, is introduced by ***Federal Products Corp.***, Providence, marking the first radical improvement in micrometers in 70 years. It combines the accuracy, over the full one inch (0-1 in.) of the micrometer screw, and the precision of the dial indicator.

It can also be used as a dial indicator comparator without the necessity of setting to a master; the micrometer feature furnishes its own precision setting.

The micrometer in use showing the dial indicator

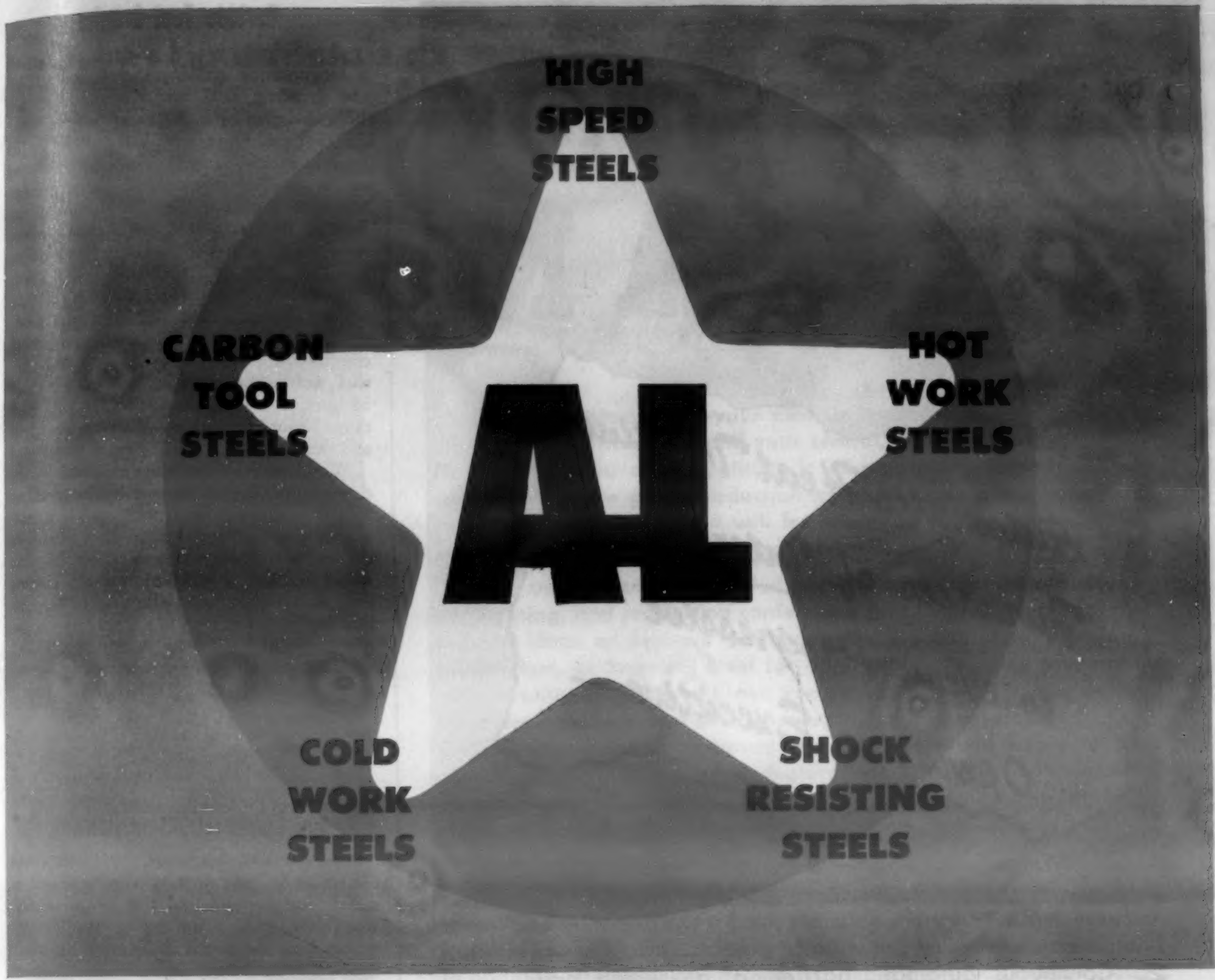
As a micrometer, the spindle can be brought in contact with the work until the indicator hand indicates "0" and the measurement is then read in the barrel and thimble. As an indicating comparator, it can be set to the nearest thousandth of an inch, and the variation from that setting can then be read on the dial.

In both the above cases the anvil pressure is constant and, therefore, the real accuracy of the instrument can be realized, independent of "feel." The use of the micrometer as a comparator makes it highly advantageous for short runs and equally valuable as a direct reading instrument where frequent changes occur in dimensions and tolerances. A single micrometer can replace a complete series of ordinary go and no-go gages.

Automatic Filter for Plating

A new automatic filter for plating room service, produced by *Udylite Corp.*, Detroit 11, features a positive plug type multiport valve that can be manipulated with one control lever to prime the pump, feed slurry, backwash, build filter cake, clean the filter or transfer a solution from one tank to another.

The filter structure consists of rigid porous ceramic elements arranged radially with a center channel to carry the filtrate. The filtering elements are permanent, and the filter oil is deposited on the outside of these elements to form the filter cake.


HIGH
SPEED
STEELS
CARBON
TOOL
STEELS
HOT
WORK
STEELS
AL
COLD
WORK
STEELS
SHOCK
RESISTING
STEELS

Carbide Tool Grinder

A new carbide tool grinder, embodying a reciprocating action principle that builds the grinding skill into the machine, has been designed by *E. F. Hager & Son*, 98-02 217th Lane, Queens Village 9, N. Y. Its built-in reciprocating action unit, consisting of a toolholder-protractor arrangement, pivots on a definite fixed center and cannot float. The grinder is said to eliminate guesswork on angles and free-hand operation.

Carbide tools up to and including 1½-in. sq. for lathes, automatic screw machines, milling cutters, offset tools, spiral reamers, counter-bores and any other carbide-tipped tool within the range of the machine can be ground on this tool grinder. A wide range of attachments are available for these and other types of carbide-tipped tools.

When the tool has been clamped to the desired position in the toolholder and set by the protractors for cutting and clearance angles, the uniform reciprocating action of the tool across the rough-grinding diamond wheel results in a keen, durable cutting edge and straight face. The adjustable, vise-like toolholder can be slid from the rough-grinding wheel to the finish-grinding wheel, without removing the tool or changing the angular settings.

Plywood Compositions in Railway Car

Two modern materials, "Plymetl" and "Phemaloid," the first a combination of metal and plywood and the second a plywood, are finding interesting applications where light weight is desired. It is made by the *Haskelite Mfg. Corp.*, Dept. 1, Grand Rapids 2, Mich. One striking use is in a one-man railway inspection car made by Fairmont Railway Motors, Inc., Fairmont, Minn.

Contributing to the lightness of the car is an aluminum alloy frame. The "Plymetl" is used for the tool tray floors on either side of the car. They act as giant gusset plates to maintain frame squareness. The "Phemaloid" is used in seat material, being strong and weather-resistant.

Stainless Steel Filter Medium

A stainless steel filter medium has been developed by the *Micro Metallic Co.*, 99-16 Metropolitan Ave., Forest Hills, N. Y. These filters are made from fully alloyed stainless steel powder, the particles of which are welded together at the points of contact into a strong porous body, which in the form of thin sheets can be bent about a small radius. Conventional resistance welding techniques can be used to fabricate complicated apparatus.

This stainless steel material can be used as the filter medium or porous element in nearly all types of conventional apparatus. Applications include: filters, aeration units, breathers, flame arrestors, pressure snubbers, and selective separations of fluids.

Viewer for Measuring by Optical Methods

A viewer to obtain accurate measurements of gage blocks, anvils, sealing surfaces and other precision articles by optical methods is announced by *Optron Laboratory*, Dayton 6, Ohio.

The optical viewer permits accurate measurement of precision articles

Interference patterns are both illuminated and viewed on a line perpendicular to the plane of the pattern. The image of any convenient scale can be superimposed on the interference pattern itself, permitting comparisons of straightness or direct measurements between interference bands without using a ruler or straightedge.

Plaster of Paris Impregnant

A new type of plaster of Paris impregnant for plaster of Paris and Hydrocal forms for service in match plates, core boxes, dies for hydropress work, stretch press dies, etc. is announced by *Furane Plastics & Chemicals Co.*, 5233 W. San Fernando Rd., Los Angeles 26. Type resin XP is for plaster and XR for Hydrocal.

Plaster of Paris forms, patterns, dies, contour blocks, etc. are prepared and poured exactly in their usual manner. After the parts have been fully shaped and thoroughly dried, the liquid resin impregnant is applied by dipping, brushing or spraying, and then the parts are cured in an oven.

A very hard, bone-like structure is developed with physical properties comparable to cast plastics. Toughness may be acquired through prior inclusion of large fiber fillers. Dimensions are held accurately, as there is no shrinkage whatsoever either during cure or in service. Temperature resistance of the impregnated forms is considerably higher than straight plaster of Paris or Hydrocal. Water and chemical resistance are increased substantially.


H-P-M Finger Tip Control
SPEEDS UP
THE DIE-CASTING CYCLE
AND ELIMINATES
OPERATOR FATIGUE
Fully automatic except for ladling metal into the "cold" chamber, H-P-M high pressure metal die-casting machines reduce the "human element" to an absolute minimum. All machine actions are controlled by a single multiflex timer, conveniently located at the operator's station. Hand switches are also provided for independent manual control of each machine action.
Hydraulic power is available for pulling cores, thereby eliminating all manual effort of freeing intricate metal castings from the mold. The H-P-M straight-line hydraulic mold clamp permits molds to be quickly interchanged. No adjustments are necessary to install molds of different thickness.
Have you considered die casting your metal parts? High pressure die castings have ideal mechanical specifications, and cost very little more than low pressure die castings.
Equipped exclusively with H-P-M hydraulic pumps, valves and controls, H-P-M die-casting machines are designed for high speed, heavy duty service. Investigate these revolutionary "all-hydraulic" machines. Write today for H-P-M bulletin 4402, or better yet, call in an H-P-M engineer to discuss your particular problems.
THE HYDRAULIC PRESS MANUFACTURING CO.
Mount Gilead, Ohio, U. S. A.
Branch Offices: New York, Philadelphia, Cleveland, Detroit and Chicago. Representatives in Principal Cities
HPM
All-Hydraulic · High Pressure
DIE-CASTING MACHINES
REVOLUTIONIZING PRODUCTION WITH HYDRAULICS SINCE 1877

Meetings and Expositions

NATIONAL PLASTICS EXPOSITION. New York, N. Y. April 22-27, 1946.

OPEN HEARTH STEEL AND BLAST FURNACE & RAW MATERIALS CONFERENCE, annual meeting. Chicago, Ill. April 24-26, 1946.

AMERICAN CERAMIC SOCIETY, annual meeting. Buffalo, N. Y. April 28-May 1, 1946.

AMERICAN FOUNDRYMAN'S ASSN., annual meeting. Cleveland, Ohio. May 6-10, 1946.

NATIONAL ASSOCIATION OF CORROSION ENGINEERS, annual meeting and exhibition. Kansas City, Mo. May 7-9, 1946.

NATIONAL MARINE EXPOSITION. New York, N. Y. May 20-25, 1946.

AMERICAN IRON & STEEL INSTITUTE, general meeting. New York, N. Y. May 23, 1946.

SOCIETY OF AUTOMOTIVE ENGINEERS, semi-annual meeting. French Lick Springs, Ind. June 2-7, 1946.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Aviation Division meeting. Los Angeles, Calif. June 3-6, 1946.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Oil and Gas Power Division meeting. Milwaukee, Wis. June 12-15, 1946.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, semi-annual meeting. Detroit, Mich. June 17-20, 1946.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Applied Mechanics Division meeting. Buffalo, N. Y. June 21-22, 1946.

AMERICAN SOCIETY FOR TESTING MATERIALS, annual meeting. Buffalo, N. Y. June 24-28, 1946.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, corrosion conference. Gibson Island, Md. July 15-19, 1946.

Plants and Slants

Stockholders of *Michigan Die Casting Co.*, Detroit, and *Gerity-Adrian Mfg. Corp.*, Adrian, Mich., voted on March 4 for the merger of their companies. Gerity-Adrian specializes in chromium, cadmium and silver plating of die castings.

The *Molybdenum Corp. of America* announces that *Cleveland Tungsten, Inc.*, 10200 Meech Ave., Cleveland, has become one of its subsidiaries.

Joseph A. Weiger, vice president, P. R. Mallory & Co., Inc., and Henry D. Weed,

Jr., manager, Resistance Welding Alloy Div., same company, have resigned to form a new manufacturing firm, *Weiger, Weed & Co.*, 11644 Cloverdale Ave., Detroit. They will specialize in resistance welding electrodes, electrical contacts and special metallurgical products.

Barium Steel Corp. has acquired control of *Republic Industries, Inc.*, this being the fourth acquisition in the past 18 months. Republic makes engines for airplanes and automobiles and hydraulic equipment.

Acquisition of the McCook, Ill. government sheet mill by the *Reynolds Metals Co.*, will speed the conversion of tremendous quantities of aluminum battle scrap to meet building needs. Much of the scrap will be converted to corrugated sheet for roofs and walls for housing and transportation equipment.

Monsanto (Canada) Ltd. now has under construction a polystyrene plant whose product will be marketed as "Lustron." The base material, styrene monomer, will be purchased from the *Polymer Corp.*, a company owned by the Canadian government and located at Sarnia, Canada.

The *Pittsburgh Corning Corp.* announces plans for a $300,000 expansion for manufacture of "Foamglas," a glass insulation material, at Port Allegany, Pa.

Koppers Co., Inc., Pittsburgh, has acquired the entire common stock of *Wailes Dove-Hermiston Corp.*, Westfield, N. J., manufacturer of bituminous coatings for protection of steel against corrosion.

The *Ideal Commutator Dresser Co.* has changed its corporate name to Ideal Industries, Inc.

Federated Metals Div., American Smelting & Refining Co., has arranged with *Gardiner Metal Co.*, Chicago, to produce and market the entire line of Gardiner extruded solders.

Plymold Corp., Lawrence, Mass., has formed the *Molded Plywood Div.* and has acquired additional buildings for manufacture.

Polyplastex, maker of sealers of porous metal castings, etc. has a new location at 92-35 Horace Harding Boulevard, Elmhurst, New York City.

Pettibone Mulliken Corp. has purchased *Beardsley & Piper Co.*, maker of foundry equipment for the past 25 years.

Pan American Alloys, Inc., New Orleans, maker of aluminum alloy castings, has purchased buildings formerly operated by National Machine & Foundry Co. at Scottdale, Pa. Production of aluminum alloy castings in sand and permanent mold, as well as brass and bronze castings, was scheduled to start March 15.

The New York City district office of the *Kuhlman Electric Co.*, maker of transformers and rocking electric furnaces, will henceforth be known as *J. E. Bevan Co., Inc.*

The *Foundry Equipment Co.*, Cleveland 13, has acquired the corporate name, trade name, good will, patents, drawings and other assets of the *McCann Furnace Co.*, that city.

The *J. M. Ney Co.*, established in 1812 and chiefly concerned with manufacture of precious metal alloys for the dental industry, has expanded its manufacture of gold, platinum and palladium alloys for contacts in potentiometers and precision instruments in aviation and radar.

Attwood Iron Industries, Grand Rapids 2, Mich., is a new enterprise that will produce gray iron, semi-steel and other ferrous castings in the spring. Officials of the new concern are key men of Attwood Brass Works.

Delamar McWorkman, formerly director and plant manager of Noblitt-Sparks Industries, Inc., Columbus, Ind., has formed a consulting engineering firm, called the *Willard Engineering Co.*, at Miamisburgh, Ohio. The company will specialize in manufacturing methods.

House Organ Notes

Electronics Digest, Westinghouse Electric Corp., First Quarter, 1946.

A new 50-page illustrated house organ, to be issued quarterly, is off the press and includes articles on stratovision, Mot-O-Trol, fluorescent lighting, electrolytic tin plating, X-ray inspection and electrostatic air cleaning. The articles are non-technical digests of material previously published in technical magazines.

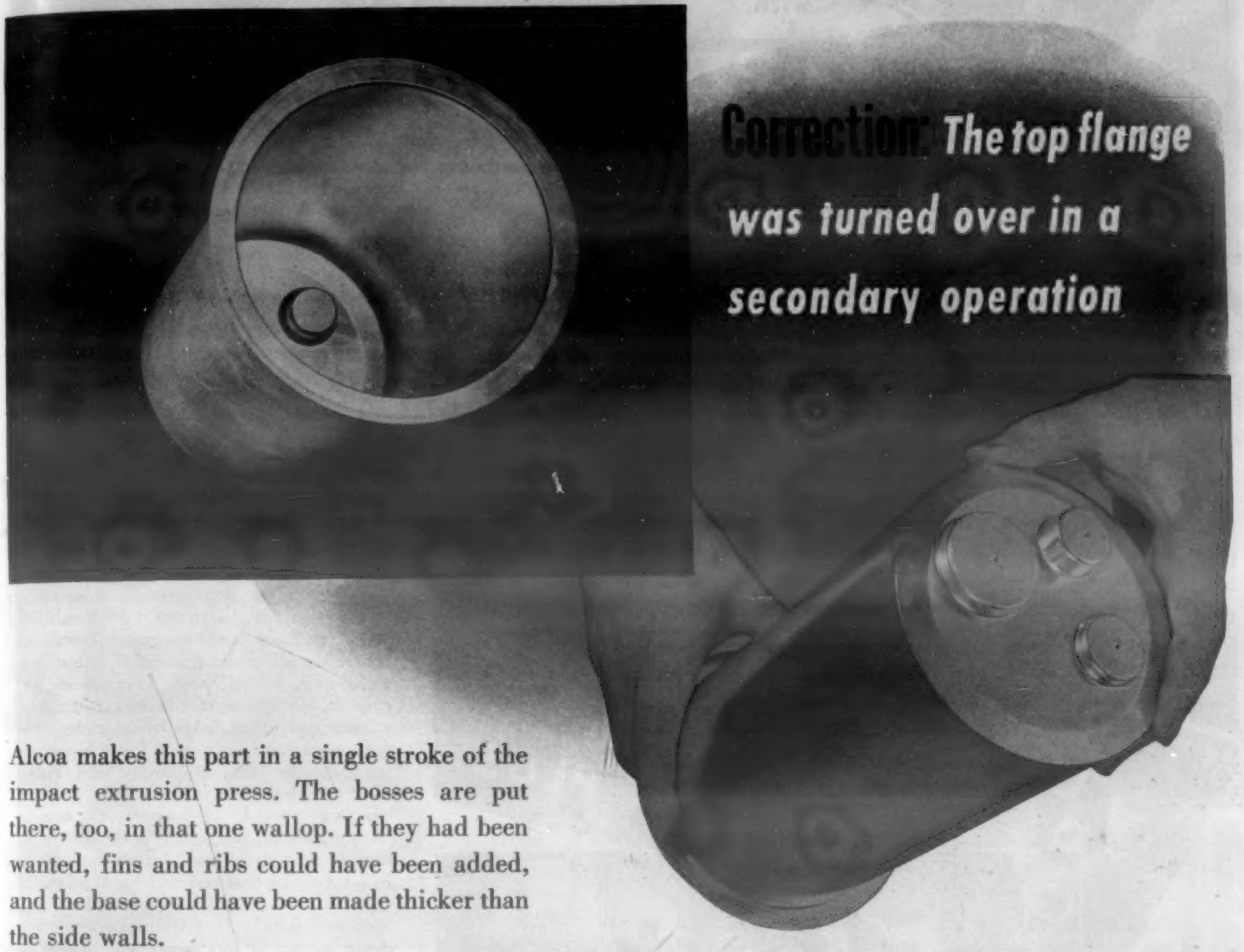
Houghton Line, E. F. Houghton & Co., February, 1946.

The editor develops the idea through quotations from the U. S. Constitution and various authorities that Harry S. Truman is not President of the United States, but still Vice-President, who is merely serving as President. Apparently there is nothing in the Constitution nor in books written by experts on the Constitution that suggest that a Vice-President automatically becomes President on the original President's death. In short, we won't have another President until he is duly elected. (Harry, we've been showing you too much deference—Editor.)

The Lamp, Standard Oil Co. of New Jersey, December, 1945.

"Speaking of jet propulsion, Newton's third law merely formalized a principle that more ancient people had already discovered. Two thousand years or so ago, an Alexandrian inventor named Heron worked out plans for an aeolipile, a jet-powered vessel that revolved on a shaft under the reaction power of jets of steam, much as an automatic lawn sprinkler of today keeps revolving when water spurts from its nozzles. Later, thirteenth-century Chinese used the reaction principle to make gunpowder rockets for warfare against the Mongols. Since that time rockets have been, on and off, a plaything or a major weapon of the world's armies. When Francis Scott Key sang of 'the rockets' red glare,' he was talking of these same instruments as hurled by the British against Fort McHenry. More recently, the British were on the receiving end when the Nazis hurled V-2 across the Channel. The Japanese got a taste of this weapon on the shores of Iwo Jima and

Here's another of Alcoa's "One Wallop" Jobs



Alcoa makes this part in a single stroke of the impact extrusion press. The bosses are put there, too, in that one wallop. If they had been wanted, fins and ribs could have been added, and the base could have been made thicker than the side walls.

Remember how you once figured on three or four drawing operations to make a part like this? Punches, dies, press time, and intermediate heat treatments all ran your costs up *high*. And even then, you'd have to find some way of tacking those bosses on the bottom.

Because Alcoa Aluminum impact extrusions give you so much more to start with, less machine work is required to finish them. Think what this does to your production time and costs! For quotations on impact extrusions, call the nearby Alcoa office, or write

ALUMINUM COMPANY OF AMERICA, 2162 Gulf Building, Pittsburgh 19, Pennsylvania.

ALCOA FIRST IN ALUMINUM

other Pacific isles. The rocket is brand new and very old."

Aluminum Progress, Reynolds Metals Co., February, 1946.

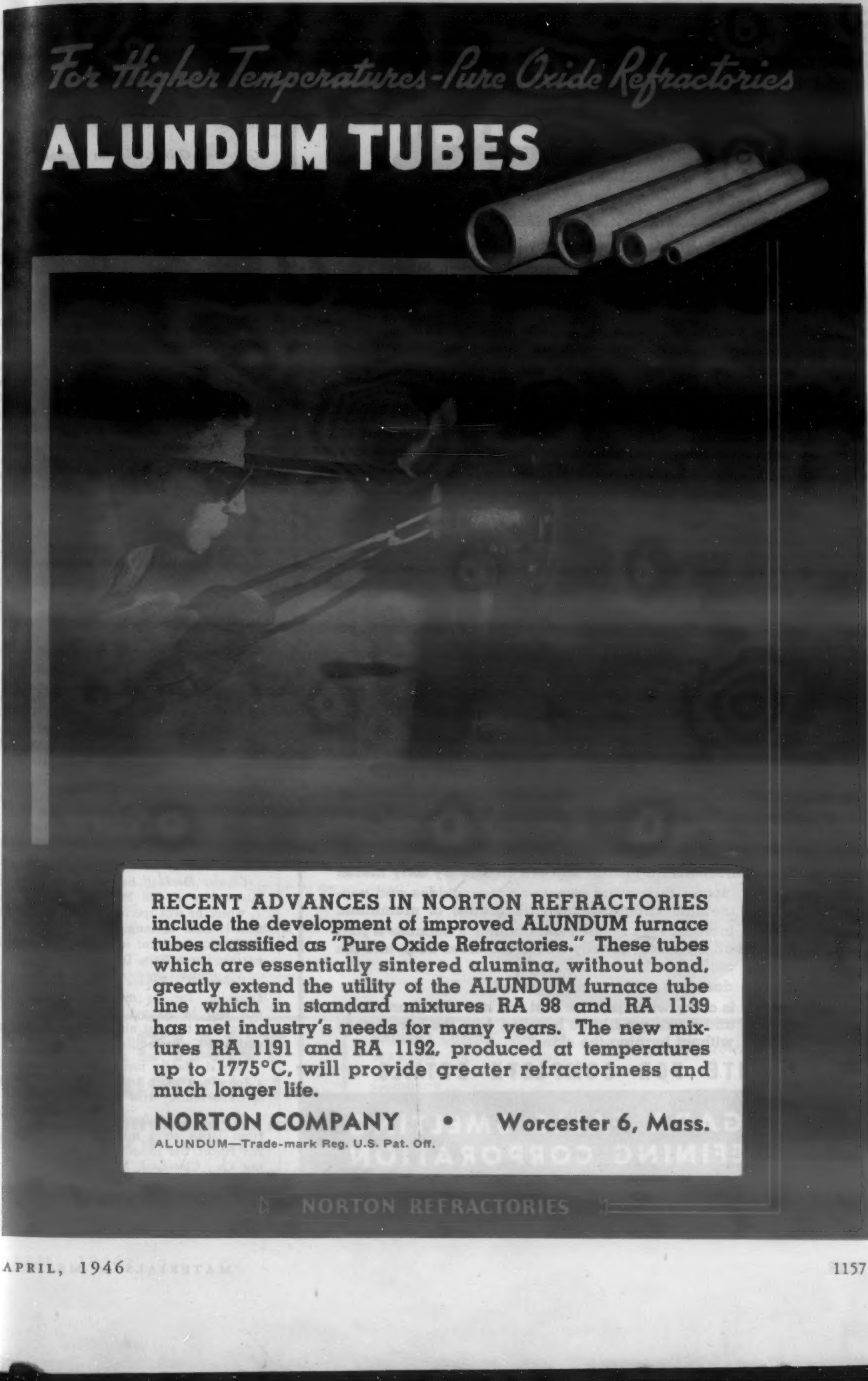
"You've undoubtedly heard of the 'Bicycle Built for Two'—well, here are the lightest two-horsepower ever built for a bicycle! This all-aluminum bicycle engine weighs only 32 lb. and is capable of driving the average bicycle at speeds up to 35 miles per hr. It's a smoother ride without the shimmying caused by the conventional heavier engines, and the bicycle is much easier to handle when not running because of the engine's lightness. A novel inverted installation and a direct friction drive on the rear wheel are patented features of this aluminum engine which allow for a simple, more compact motorbike. The engine is a two-cycle, mechanical valve type, and fits all standard bicycles. It was made by Reynolds Metals Co., Louisville, and is now undergoing final tests."

Nickel Cast Iron News, International Nickel Co., Inc., 1st Quarter, 1946.

"Inoculation, common practice during the war, is certain to continue in the hands of the foundryman for eliminating heretofore unexplained variations in the quality of his product. Inoculation has been traced to a reaction which, when executed in its proper time and place, forces the crystallization of graphite in the stable system. Their function is to produce a narrower and more dependable range of physical properties for metal of a given composition. Along with the improvement in structure comes one in toughness, machinability, wear resistance and strength. Inoculants containing alloys, such as nickel, chromium, manganese, molybdenum, titanium or zirconium, in addition to silicon, calcium, aluminum and other deoxidizing or degasifying constituents, are used for the specific improvements they confer beyond either their alloying influence or their graphite structure control. Among wear resisting castings, a high percentage are treated with inoculants in the course of their production. In a survey of heat resisting applications of cast iron, over 40% of the castings had been inoculated. In certain foundries the entire output is inoculated, and the practice has become important, particularly in shops producing automotive, diesel, compressor, hydraulic machinery and machine tool castings."

Rustless Recorder, Rustless Iron & Steel Div., September, 1945.

"Several parts of the famous Garand rifle were made throughout the war from Rustless stainless steel. These parts include the gas cylinder, piston plunger cap, and gas cylinder lock. Stainless steel was specified because of its resistance to corrosion and heat, and especially its resistance to the corrosive effects of the products of combustion in an automatic rifle. At the request of the armed services, Rustless Research Laboratory also has done much work on a blackening process for stainless steel which would not impair its resistance to corrosion. The first research was done on bayonet clips, and in 1942 a Rustless black oxide coating was developed which the services


For Higher Temperatures-Pure Oxide Refractories
ALUNDUM TUBES
RECENT ADVANCES IN NORTON REFRACTORIES include the development of improved ALUNDUM furnace tubes classified as "Pure Oxide Refractories." These tubes which are essentially sintered alumina, without bond, greatly extend the utility of the ALUNDUM furnace tube line which in standard mixtures RA 98 and RA 1139 has met industry's needs for many years. The new mixtures RA 1191 and RA 1192, produced at temperatures up to 1775°C, will provide greater refractoriness and much longer life.
NORTON COMPANY • Worcester 6, Mass.
ALUNDUM—Trade-mark Reg. U.S. Pat. Off.
NORTON REFRACTORIES

have been evaluating. The Springfield Armory used this coating on gas chambers for the Garand rifle, and other manufacturers were using it on instrument parts at the end of the war. The idea was to camouflage the bright stainless steel so it wouldn't reveal the presence of the fighting man as he carried his rifle in combat."

Grits and Grinds, Norton Company, Vol. 30, No. 7.

"For many years our country depended upon Germany for its optical lenses and instruments. When the war broke out, we were not prepared to manufacture optical elements in quantities needed by the armed forces. Lenses were still being produced by slow, old-fashioned methods, employing loose abrasive grain and charged diamond laps. The metal bonded diamond lens generating wheel transformed the manufacture of lenses from a custom-made job to a production basis. Instead of hours, it became a matter of seconds to generate a lens curve. The edging and beveling of lenses, formerly done with slow cutting artificial abrasive wheels, is now being accomplished with fast cutting metal bonded diamond wheels more accurately and economically than ever before. Optical prisms for binoculars, range finders, and periscopes were formerly ground with artificial abrasive wheels. They are now ground at unbelievably fast rates, accurately and economically, on heavy-duty vertical spindle grinders mounting 10-in. and 18-in. diam. cylinder type diamond wheels—metal bonded for roughing and resinoid bonded for finishing."

News of Engineers

H. Malcolm Priest has become manager of the railroad research bureau, U. S. Steel Corp. subsidiaries and will supervise research and design in light weight railroad equipment and other mobile structures.

S. B. Knutson has been made general superintendent, Flexsteel Div., Ambridge plant, National Electric Products Corp., Pittsburgh. He has done metallurgical work with Carnegie-Illinois, McQuay-Norris Mfg. Co. and Standard Steel Spring Co.

Charles Davidoff has opened offices and laboratories at 198 Broadway, New York 7, where he will specialize in chemical and metallurgical investigations. He was formerly vice president in charge of chemical engineering at Sam Tour & Co.

Robert W. Ritchie has joined Bliss & Laughlin, Inc. as metallurgical engineer and will be located at the Harvey, Ill. plant. For the past nine years he has been with the Carnegie-Illinois Steel Corp.

Carl A. Zapffe, metallurgist, has opened a consulting office and research laboratory at 6410 Murray Hill Road, Baltimore 12.

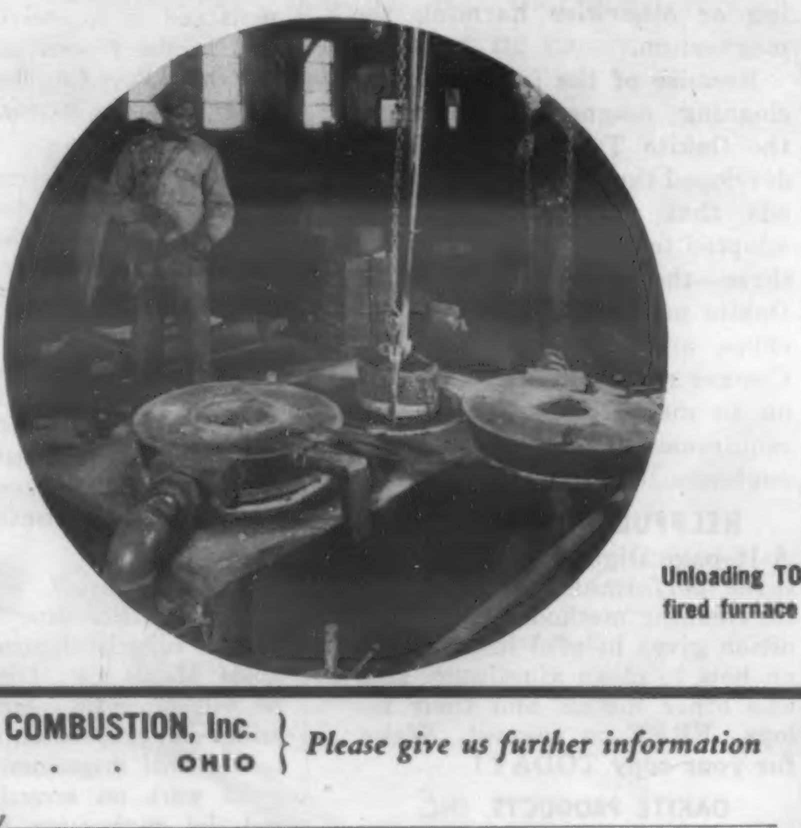
Donald L. Colwell, recently returned from Japan on a mission for the Army Air Forces, has joined the National Smelting Co., Cleveland, his permanent headquarters to be announced later. He has had outstanding experience with light metal alloys and has contributed numerous articles to the technical press on die casting and

YOU'RE THROWING MONEY AWAY WITH YOUR OLD CRUCIBLE FURNACES

Scrap them At a Profit

Here is a "revolutionary" TOP fired crucible melting furnace . . . it's different . . . it's new . . . and it's better. This TOP Fired tandem furnace has two crucibles, loaded at all times . . . they are fired alternately. While the first crucible is heated, the flue gases from it preheat the second crucible. While the metal from the first crucible is being poured, a third crucible replaces the removed crucible to receive cold metal. The covers are cam lifted and swung backward independent of one another, allowing each side to be alternately fired. The advantages are so outstanding that no one can afford to use the older type. Refer to column on left-hand side . . . *write today.*

1. 25 to 30% fuel saved on aluminum and magnesium. 40 to 50% fuel saved on brass and copper.
2. 50 to 100% longer pot life.
3. 50 to 100% longer lining life.
4. 50 to 100% longer cover life.
5. 50 to 100% longer burner life.
6. Easy to charge. (No flame through cover)
7. Far lower metal loss. (Flame does not impinge on metal)
8. Faster heating. (Combined radiant and convection heating)
9. Less slagging. (Less slagging and no slag build up possible)
10. Lining is easy to replace. (No burner ports)
11. Burners easy to inspect and replace. (Change in 15 minutes)
12. Burners cannot plug. (Burners in top where slag or metal cannot reach them)
13. Pure metal. (Neutral pressure on metal surface allows charcoal or atmosphere to be used)
14. Furnace can be flued through the floor to the outside, eliminating heat and gases in foundry.
15. No leakage of cover. (No flame through or around cover)
16. Quiet operation.
17. Unobstructed flueing. (Flued at bottom and charge does not affect it)
18. Metal is visible at all times and temperature can be taken at any time, without shutting off burners.



Unloading TOP fired furnace

RADIANT COMBUSTION, Inc.

BUILDERS OF EVERY TYPE (OIL, GAS, ELECTRIC) OF HEAT TREATING FURNACE

WARREN . . OHIO

RADIANT COMBUSTION, Inc.
WARREN . OHIO } *Please give us further information*

Company____________________

Your Name____________________

Address____________________

City__________ State__________

nonferrous metals. He is a prominent member of technical societies.

Emery B. Gebert has joined Hungerford Research Corp., Murray Hill, N. J., as chief powder metallurgist. Previous connections have been with the Koebel Diamond Tool Co., Amplex Div., Chrysler Corp., American Electro Metal Corp., and Metals Disintegrating Co.

Harold C. R. Carlson has become chief engineer, Chas. Fischer Spring Co., 749 Atlantic Ave., Brooklyn 17, N. Y.

After 25 years with Ford Motor Co. in steel, glass, rubber, plastics and magnesium plants, *Frank G. Shaub* has become Detroit representative for Chambersburg Engineering Co. While with Ford he did research and development on the "direct forging project," where forgings were produced from molten metal.

Eugene D. Milener has been made coordinator of general research, American Gas Assn., New York. He is a graduate of Baltimore Polytechnic Institute and University of Maryland and studied engineering at John Hopkins University.

Stephen D. Garst has joined the Bjorksten Laboratories as a chemical metallurgist, having previously been with the Dodge Chicago plant, Chrysler Corp. He has worked for several years with the Federal government and Socony Vacuum Oil Co. as a chemical engineer and metallurgist. *Luther L. Yaeger* has joined the same company as a research chemical engineer in the plastics department, having been with the Youngstown Sheet & Tube Co.

Creston E. Kite, who has specialized in metallurgical, chemical and engineering problems relating to heat treating operations and in engineering product application to the process industries, has joined General Alloys Co., Boston 27, as assistant to the president, having left E. F. Houghton Co.

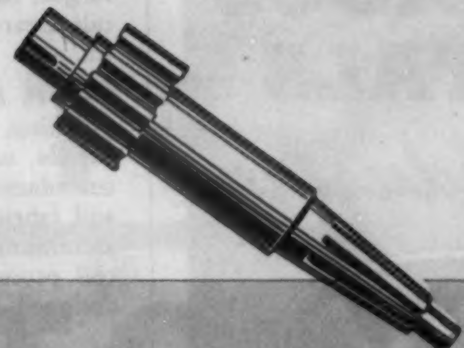
Earl A. Long, former assistant director, Los Alamos atomic bomb laboratory, has become professor in the University of Chicago's new Institute for the Study of Metals. Previous to his atomic work he was a college professor.

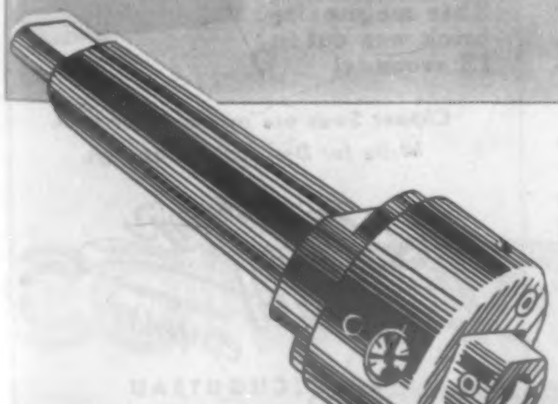
L. E. Osborne, who joined Westinghouse at the age of 16, recently was named senior operating vice president, Westinghouse Electric Corp., responsible for all manufacturing units of the company. His earliest experience was connected with the machine shop.

G. W. Birdsall, technical editor and writer, formerly with *Steel* magazine, has become editorial department manager, Reynolds Metals Co., Louisville, Ky., where he will supervise company technical magazines and preparation of technical articles for national magazines. He has done editorial work on several technical journals and did engineering work for the Ideal Electric & Mfg. Co., Mansfield, Ohio.

Russell L. Peck has been made refractories engineer by Norton Co.

Grover C. Schantz has become production superintendent of Optimus Equipment Co., Matawan, N. J., having been previously plant superintendent at Metalwash Machinery Co., Irvington, N. J.




C. B. Willmore has joined William F. Jobbins, Inc., Aurora, Ill., as chief metallurgist, having spent 27 years in metallurgical research with Aluminum Co. of America.

R. P. Kytle, Jr. has become manager of planning, Reynolds Alloys Co., a Reynolds Metals subsidiary. Among his technical contributions are developments in rolling and fabricating practices for rolling strong aluminum alloy and common alloy by the coil process on the first 4-high cold mills designed for that purpose.

Briefs on Associations, Promotions and Education

The Industrial Diamond Assn. of America has just been formed to promote the progress and development of the industrial diamond and diamond tool industry. Athos D. Leveridge, 501 Lexington Ave., New York, is executive director and secretary-treasurer. Charter membership comprises manufacturers of diamond tools, processors, importers and distributors for industry.

William W. Coutts has become executive vice-president of Gray Iron Founders' Society, Inc., succeeding W. W. Rose, who has retired because of ill health. He was assistant secretary, National Screw Machine Products Assn., and prior to that served as business specialist with the OPA at Washington, specializing in products and processes in the metals field. According to the announcement, he is a "human and meetable sort of chap."

The National Open Hearth Steel Committee and the Blast Furnace and Raw Materials Committee of the American Institute of Mining & Metallurgical Engineers will hold its twenty-ninth annual conference at the Palmer House, Chicago, April 24-26. According to the announcement, "All operating men, repair and maintenance men, metallurgists, ceramic and refractory engineers, observers, chemists, and any others interested in the production of more steel, better steel and cheaper steel and in any of the problems connected with the reduction of iron ore in the blast furnace are invited to attend."

Plans have been completed for the first National Instrumentation Conference and Exhibit, to be held in the William Penn Hotel, Pittsburgh, Sept. 16-20. It is sponsored by the Instrument Society of America. Over 75 companies indicate that they will be represented. A series of short educational courses will be conducted by Dr. B. R. Teare, professor of electrical engineering at Carnegie "Tech."

The Metal Powder Assn. will hold its annual spring meeting at the Waldorf-Astoria Hotel, New York, on June 13. The meeting will be open to anyone interested in the subject, whether a member or not. Robert G. Kenly, New Jersey Zinc Sales Co., is chairman of the program committee.

The Products of Tomorrow Exposition, which had been scheduled to open at the Chicago Coliseum April 27, has been postponed indefinitely. It may be held in the

C. B. Willmore has joined William F. Jobbins, Inc., Aurora, Ill., as chief metallurgist, having spent 27 years in metallurgical research with Aluminum Co. of America.

R. P. Kytle, Jr. has become manager of planning, Reynolds Alloys Co., a Reynolds Metals subsidiary. Among his technical contributions are developments in rolling and fabricating practices for rolling strong aluminum alloy and common alloy by the coil process on the first 4-high cold mills designed for that purpose.

Briefs on Associations, Promotions and Education

The Industrial Diamond Assn. of America has just been formed to promote the progress and development of the industrial diamond and diamond tool industry. Athos D. Leveridge, 501 Lexington Ave., New York, is executive director and secretary-treasurer. Charter membership comprises manufacturers of diamond tools, processors, importers and distributors for industry.

William W. Coutts has become executive vice-president of Gray Iron Founders' Society, Inc., succeeding W. W. Rose, who has retired because of ill health. He was assistant secretary, National Screw Machine Products Assn., and prior to that served as business specialist with the OPA at Washington, specializing in products and processes in the metals field. According to the announcement, he is a "human and meetable sort of chap."

The National Open Hearth Steel Committee and the Blast Furnace and Raw Materials Committee of the American Institute of Mining & Metallurgical Engineers will hold its twenty-ninth annual conference at the Palmer House, Chicago, April 24-26. According to the announcement, "All operating men, repair and maintenance men, metallurgists, ceramic and refractory engineers, observers, chemists, and any others interested in the production of more steel, better steel and cheaper steel and in any of the problems connected with the reduction of iron ore in the blast furnace are invited to attend."

Plans have been completed for the first National Instrumentation Conference and Exhibit, to be held in the William Penn Hotel, Pittsburgh, Sept. 16-20. It is sponsored by the Instrument Society of America. Over 75 companies indicate that they will be represented. A series of short educational courses will be conducted by Dr. B. R. Teare, professor of electrical engineering at Carnegie "Tech."

The Metal Powder Assn. will hold its annual spring meeting at the Waldorf-Astoria Hotel, New York, on June 13. The meeting will be open to anyone interested in the subject, whether a member or not. Robert G. Kenly, New Jersey Zinc Sales Co., is chairman of the program committee.

The Products of Tomorrow Exposition, which had been scheduled to open at the Chicago Coliseum April 27, has been postponed indefinitely. It may be held in the

DO YOU NEED A BETTER REFRACTORY?

● Corhart Electrocast Refractories are high-duty products which have proved considerably more effective than conventional refractories in certain severe services. If your processes contain spots where a better refractory is needed to provide a balanced unit and to reduce frequent repairs, Corhart Electrocast Refractories may possibly be the answer. The brief outline below gives some of the basic facts about our products. Further information will be gladly sent you on request.

Corhart Refractories Company, *Incorporated*, Sixteenth and Lee Streets, Louisville 10, Kentucky.

"Corhart" is a trade-mark, registered U. S. Patent Office.

PRODUCTS

The Corhart Refractories Company manufactures Electrocast refractory products exclusively. Corhart Electrocast Refractories are made by melting selected and controlled refractory batches in electric furnaces and casting the molten material into molds of any desired reasonable shape and size. After careful annealing, the castings are ready for shipment and use.

Three Electrocast refractory compositions are commercially available:

CORHART STANDARD ELECTROCAST — a high-duty corundum-mullite refractory, with density of approximately 183 lbs. per cu. ft.

CORHART ZED ELECTROCAST—a high-duty zirconia-bearing aluminous refractory, with density of approximately 205 lbs. per cu. ft.

CORHART ZAC ELECTROCAST—a high-duty zirconia-bearing refractory, with density of approximately 220 lbs. per cu. ft.

Other Corhart products are:

CORHART STANDARD MORTAR—a high-temperature, high-quality, hot-setting cement for laying up Electrocast, or any aluminous refractory.

CORHART ACID-PROOF MORTARS — rapid cold-setting, vitrifiable mortars of minimum porosities.

CORHART ELECTROPLAST—a high-temperature, hot-setting plastic refractory, designed for ramming and made from crushed Standard Electrocast.

CORHART ELECTROCAST GRAINS—Standard Electrocast crushed to desired screen size for use in many commercial applications.

PROPERTIES

Due to the unique method of manufacture, the Electrocast refractory line possesses a combination of characteristics found in no other type of refractory. Data on properties will be sent on request.

POROSITY: Apparent porosity of Corhart Electrocast refractories is practically nil—therefore virtually no absorption.

HARDNESS: 8-9 on Mineralogist's scale.

THERMAL EXPANSION: Less than that of conventional fire clay bodies.

THERMAL CONDUCTIVITY: Approximately one and one-half times that of conventional fire clay bodies.

REFRACTORINESS: Many industrial furnaces continuously operated up to approximately 3000° F. are built of Corhart Electrocast.

CORROSION: Because of exceedingly low porosity and inherent chemical compositions, Corhart Electrocast refractories are resistant to corrosive action of slag, ashes, glasses, and most non-ferrous metals as well as to disintegrating effects of molten electrolyte salt mixtures.

APPLICATIONS

Most heat and metallurgical processes present spots where better refractory materials are needed, in order to provide a balanced unit and reduce the expense of repeated repairs. It is for such places of severe service that we invite inquiries regarding Corhart Products as the fortifying agents to provide the balance desired. A partial list of applications in which Corhart Electrocast products have proved economical follows:

GLASS TANKS—entire installation of sidewalls and bottoms, breastwalls, ports, tuckstones, throats, forehearths, bushings, bowls, recuperators, etc., for lime, lead, opal and borosilicate glasses.

ELECTROLYTIC CELLS—for production of magnesium and other light metals.

SODIUM SILICATE FURNACES — sidewalls, bottoms, and breastwalls.

PIGMENT FRIT FURNACES—complete tank furnaces for melting metallic oxides and salts for pigment manufacture.

ALKALI AND BORAX MELTING FURNACES —fast-eroding portions.

BOILERS—clinker line.

RECUPERATORS—tile, headers, separators, etc.

ENAMEL FRIT FURNACES—flux walls and bottoms.

BRASS FURNACES—metal contact linings.

ELECTRIC FURNACES—linings for rocking type and rammed linings of Electroplast for this and other types.

NON-FERROUS SMELTERS—complete hearths, sidewalls, and tapping hole portions.

QUALITY ECONOMY ENDURANCE

CORHART ELECTROCAST REFRACTORIES

fall of 1946 or early 1947. It has been postponed because the "national production outlook seems so clouded."

The American Zinc Institute has canceled its anticipated convention in St. Louis in April because of the continued congestion of hotel and railroad accommodations. A meeting of active members will be held in New York during April to comply with by-laws. The executive committee and board of directors will also meet in mid-April.

A comprehensive pressure vessel research program covering materials, design, fabrication, inspection and testing of unfired pressure vessels has been started by the Welding Research Council, 29 W. 39th St., New York 18, sponsored by several engineering societies. The lack of factual information has resulted in acknowledged over-conservatism in design.

The Resistance Welder Mfgrs.' Assn. has elected as president H. B. Warren, executive vice-president, Thomson-Gibb Electric Welding Co., Lynn, Mass.

A radio and electronic equipment show will be held at the Hotel Stevens, Chicago, May 13-16 under auspices of Electronic Industries, 480 Lexington Ave., New York 17.

Named for the presidency of the American Foundrymen's Assn. in 1946-47 is Sheldon V. Wood, president, Minneapolis Electric Steel Castings Co. Members will vote for new officers on May 9 at the 50th anniversary convention and exhibit in Cleveland, opening May 6.

Seventeen scientists of the Army Technical Service Command, Wright Field, have been in the Southwest Pacific, studying prevalent causes of deterioration that affects metals, clothing and leather in equatorial areas. They flew there in a 44-passenger Army Douglas C-54.

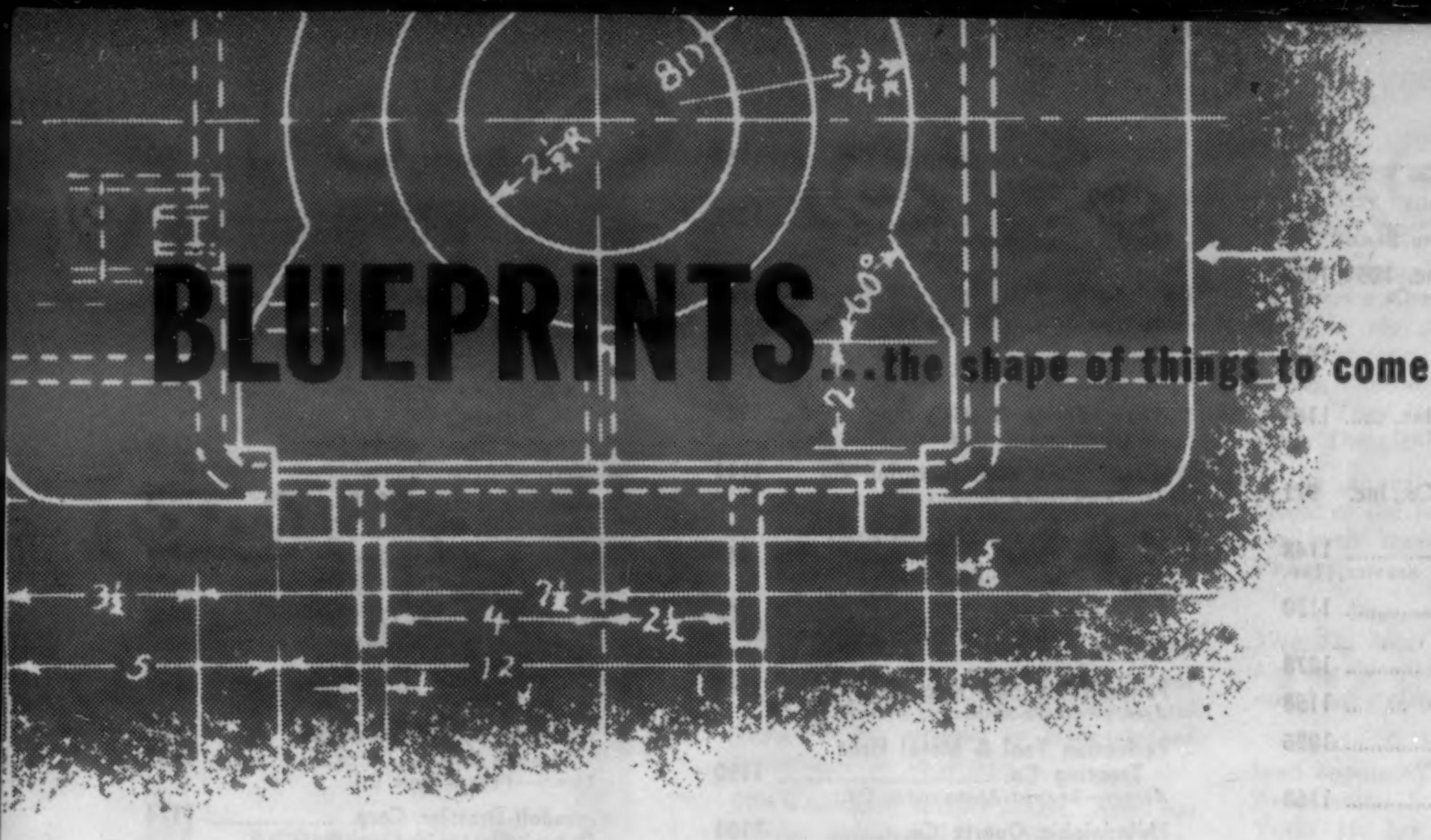
The annual award of the Morehead Medal of the International Acetylene Assn. has been made to Admiral Howard L. Vickery.

The American Welding Society, 33 W. 39th St., New York 18, has published a 156-page inspection handbook for manual metal-arc welding.

Captain S. Paul Johnston, USNR, has been appointed director of the Institute of Aeronautical Sciences, 2 E. 64th St., New York. He has written many technical articles, some appearing in *Saturday Evening Post*, *Technology Review* and *Aviation*.

The annual general meeting of the Iron & Steel Institute will be held at London May 1 and 2. Among topics to be discussed are fuel economy in iron and steel works and overheating of steel.

The use of coal-burning gas turbines on railroad locomotives may cut fuel costs to one-third or more of their present level, states the Bituminous Coal Institute.



BLUEPRINTS . . . the shape of things to come

Super Magnesium Castings

Great strides are being taken in commercial production of magnesium castings that are economical and corrosion-resistant. Zinc-containing alloys make the castings resistant even to salt water. Other new cast magnesium alloys, still in the laboratory stage, promise to be superior to aluminum base alloys in the higher temperature ranges, such as gas turbine compressors in jet aircraft engines, now made of aluminum; also for pistons and cylinder heads. Magnesium parts, because of lightness, are especially welcome in aircraft.

Substitute for Lime in Wire Drawing

There is a pronounced tendency for wire drawers to dispense with the orthodox lime lubricant in favor of a patented compound of very low alkalinity with proper wetting out properties, giving a coat that stretches with the metal and providing proper cushioning and lubrication. The new material is non-hydroscopic, there is no danger of hydrogen embrittlement. Results are better die life, more uniform and better finish, better surface for further plating, a brighter wire, a better welding wire, better tire bead and rope wire, better metal for wet drawing with liquor, copper or zinc finish. It gives good rust protection, saves in lubricant and makes cleaner plant surroundings than where lime dust is in the air.

Plastics in Comparators

Optical comparators depend on a precise shadow—no relation to "5 o'clock shadow." The shadow of the part to be inspected is thrown by a micro projector upon the comparator or screen, conventionally made of glass. Even a small crack could make this fragile glass less efficient. In the comparators of tomorrow you'll be seeing this screen made of Vinylite plastic, or reasonable facsimile. It is tough, durable and dimensionally stable. It is transparent, has flatness and freedom from curl and on it the outline of the part stands out in sharp focus. The plastic wipes clean easily, while gage lines and tolerance areas cannot be obliterated by grime.

Electropolished Stainless Steel

Seldom does an inventor of a new process envision all the future adaptations of that process. Did, for instance, the originator of the technique for electropolishing stainless steel picture that it would be used for making brilliant and shiny stainless steel jewelry such as bracelets, necklaces, midriff belts, earrings, shoe buckles, headbands, etc? Stainless steel has already received a good play in the jewelry line for wrist watch cases. Now that it can be shined up it will be a "natural." Womanhood already has a tender spot in her heart for stainless steel, the magic metal. Watch her go for it as jewelry! One dips the steel into a tank of warm citric-sulphuric solution and passes an electric current through it. A thin layer of the metal is removed, leaving a brilliant permanent polish. Disabled veterans will make the jewelry.

Magnesium as a Dampener

Magnesium is finding uses because of its dampening effect. Thus, an automobile maker has decided on magnesium alloy wheels, both because of lightness and freedom from the vibration of steel wheels, a vibration that is said to cause wear on the rubber tires. This maker is now experimenting with processes of manufacture, including sand castings. A maker of fishing tackle accessories has devised a magnesium reel. Its dampening qualities makes it silent when played out quickly.

Nylon as Valve-Seat Material

As valve-seat material for compressed air, gas, cylinder and gasoline pump equipment that will withstand pressures up to at least 3000 psi. try Nylon—if you can get it and don't push! For years our Navy used hand-lapped stop valves of metal for torpedo valve seats that must fit tightly against air pressure of 2800 psi. But dust often entered and prevented tight closing. At length the Navy used Nylon molded to a metal backing. It needed no hand-lapping, provided a 20% reduction in weight, and functioned perfectly in the presence of dust. The initial higher cost of Nylon is offset by these several advantages.

Plastics for Auto Fenders

Plastics have still far to go before used generally as bodies for automobiles because of the cost situation. But this does not preclude the possibility of specialty fenders, or perhaps use in station wagon body construction. We've already heard considerable talk about plastic fenders. They are almost impervious to dents. They bound back into smoothness from impacts severe enough to dent steel.

Sound-Dampening Paints

There are some parts of your plant where you want it particularly quiet, such as in the laboratory where perhaps concentrated work is being done on fine chemical balances. For this purpose you may in the future use a new type of paint that incorporates fine glass fibers in short lengths and which tends to deaden and damp all sound.

Rivals of Uranium

Knowledge and developments concerning energy-radiating materials expand fast. Polonium, a pure alpha-ray emitter, is now available in quantities for scientific and industrial purposes. It is finding uses where effects due to penetrating gamma radiations must be avoided. It can be used in large quantities without danger to personnel. It can be supplied in high purity as a solution and furnished co-precipitated with beryllium as an efficient neutron source. It is learned that lithium is at least theoretically able to yield 2 to 9 times as much energy as uranium, employing a simpler chain reaction such as high speed hydrogen atoms. Boron, a cheap element, could yield 25% more energy than uranium.